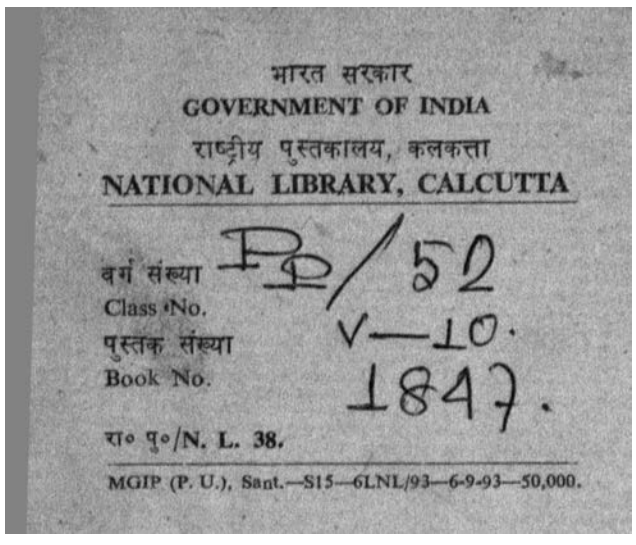
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THE

CIVIL ENGINEER AND ARCHITECT'S

JOURNAL,

SCIENTIFIC AND RAILWAY GAZETTE.

VOLUME X.

1847

LONDON:

R. GROOMBRIDGE AND SONS, 5, PATERNOSTER ROW; J. WEALE, 59, HIGH HOLBORN; WILEY AND PUTNAM, NEW YORK; GALIGNANI, AND MATHIAS, PARIS.

Printed and Published by WILLIAM LAXTON, the Proprietor, at No. 10, Fludyer Street, Whitehall.

CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

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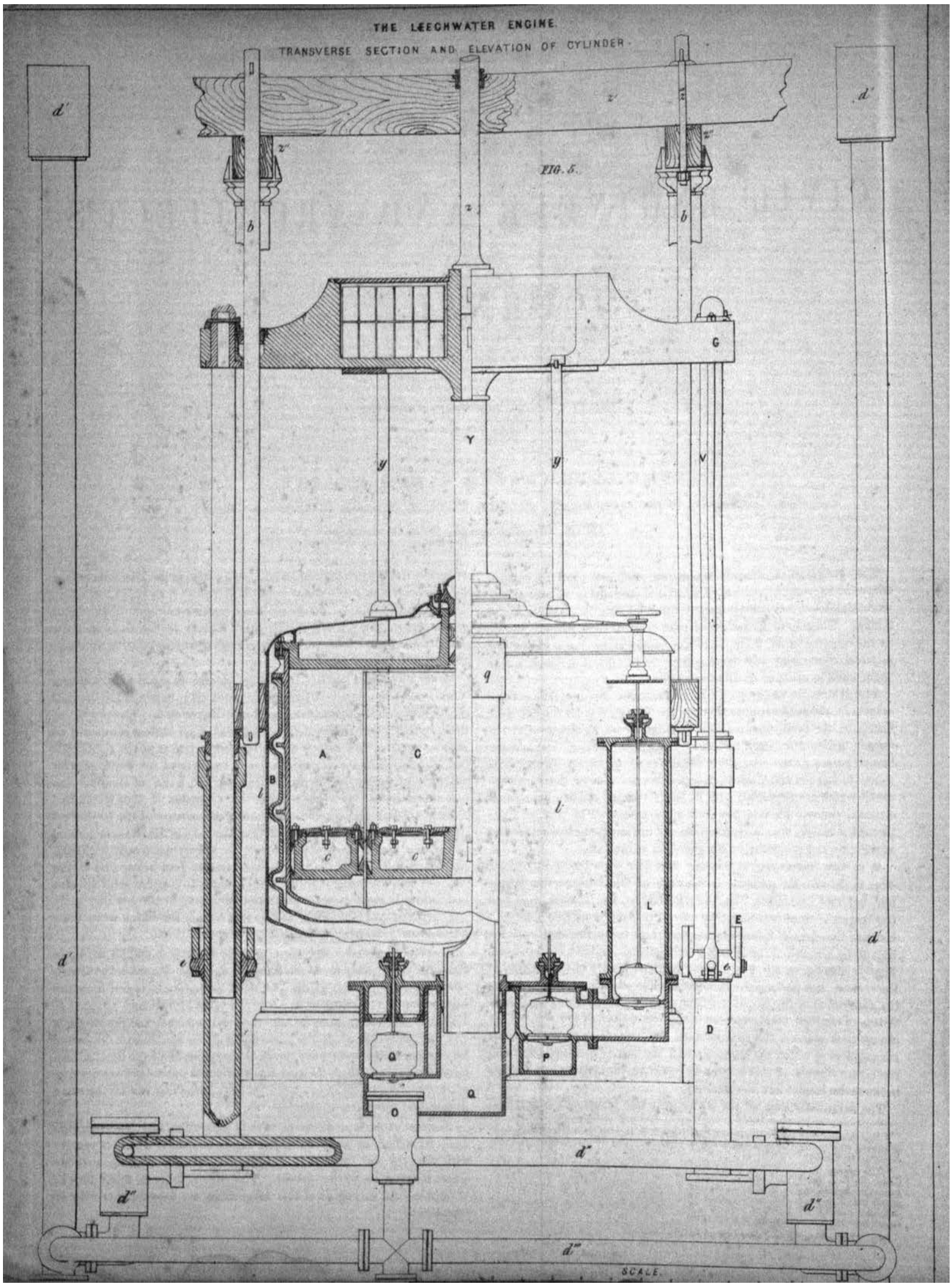
THE LEECHWATER ENGINE.

TRANSVERSE SECTION AND ELEVATION OF CYLINDER.



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CIVIL ENGINEER AND ARCHITECT'S JOURNAL.

THE LEEGHWATER STEAM ENGINE.

DRAINAGE OF THE HAARLEM LAKE, HOLLAND.—*Engineers:* Messrs. J. GIBBS and A. DEAN.

(With Two Engravings, Plates 1 *and* 2.*)*

The geographical changes which are produced near the embouchures of rivers by deposition of alluvial matter are in no part of the world exhibited in a more remarkable manner than in the delta of the Rhine. The natural operations of that river interest the antiquarian by the remoteness of their date, the geologist by their extent and physical character,* and the engineer by the grand artificial works undertaken to resist or modify their effects.

The Rhine on entering the Low Countries divides into several branches: the southernmost of these, the Whaal, reaches the sea near Kampen; the most northern branch is nearly at right angles to the former, and empties itself into the "rolling Zuyderzee," and another branch passes Rotterdam. The Rhine proper continues its enfeebled course to Leyden and Utrecht, and, nearly exhausted by the numerous canals which are connected with it, finally reaches the sea by a small artificial sluice. Its fate has been aptly compared to that of a dethroned monarch, who is deprived even of the satisfaction of attracting admiration and sympathy by the grandeur of his exit.

It is very interesting to observe how this delta has been altered even in the historic period. In the time of the Romans the Rhine had but two branches; Virgil calls it *bicornis*, and Tacitus says that the largest of these branches, that nearest to Gaul, is called *Vahalum*.† Even in the days of Charlemagne, the Rhine communicated with the Escaut, by a branch of the Meuse, which has since entirely disappeared. A great inundation, A.D. 860, destroyed the regularity of the mouths of the river. But perhaps the most remarkable alteration of all has been the conversion of the Zuyderzee from an inland fresh-water lake, such as it is described by Pomponius Mela, into a gulf of the sea. This change took place in the 13th century, and was the result of violent storms, during which the sea destroyed the barrier between itself and the lake. Traces of this barrier still exist in the islands and shoals between the Helder and Ter-shelling.

The natural division of the Rhine into two branches was first disturbed by the Roman legions under Drusus, who, in the 12th year before the Christian era, dug a canal from the Rhine to the small river *Sala*, as a military defence. This canal soon became enlarged by the force of the current into a third branch of the Rhine. A fourth branch, the Leck, was created subsequently, in a similar manner, during an insurrection under Claudius Civilis.

In our own times another important change is about to take place. The Lake of Haarlem is a large fresh water lake, between Leyden and Amsterdam, and communicates with the Zuyderzee. The project of draining this lake has been long entertained. The bottom consists of an alluvial deposit, well suited for agriculture. It was at the end of the last century, when steam engines began to be used for drainage, that the idea of employing them in draining the Lake of Haarlem was first entertained. The idea was but the extension of that which had already been practically exemplified in the drainage of the Beilm and Diem, in Holland. The longest side of the lake of Haarlem is parallel to the sea, and is separated from it by a very narrow strip of land. Moreover, the level of the lake is some twenty feet below that of the sea. When, therefore, the drained country is covered with villages and farms, it must be well protected by dikes, or the sea may some day perhaps pay the sober Dutchman a visit for which even their amphibious nature has not sufficiently prepared them.

In order to ascertain the most approved method, and at the same time the most economical manner, of draining the lake, the Dutch Government appointed a Commission of Engineers to report upon the best means and to examine the various plans of drainage adopted in England. After examining a great variety of schemes and proposals, it was determined to adopt the plan submitted by Mr. Joseph Gibbs and Mr. Arthur Dean—who have, by close attention to all the details, produced an engine which is working with great effect and astonishing economy of fuel. It is proposed to have three engines of the same power, and three sets of pumps.

The first of these engines is now in operation, and the engineers have furnished us with the following description, which is replete with valuable and interesting information, and is accompanied by ample illustrations of the details. The means taken to avoid shocks or impulses in an engine of this magnitude are especially worthy of attention.

* It is calculated (Ansted's Geology, I. 7), that seven or eight thousand millions of tons of alluvial mud are carried down by the stream annually. The greater part of this soil is deposited in Holland.

† The passage in Tacitus (Ann. II. 6,) seems somewhat inconsistent with another in Cæsar (De Bell. Gall IV. 10), where, after a sentence of which the text is evidently corrupt, and the meaning (to us at least), obscure, it is said, "Ubi Oceano appropinquat, in plures difflut partes, multis, ingentibusque insulis effectis.....multisque capitibus in Oceanum influit." It has been supposed, however, that Cæsar speaks merely of the subordinate streams and mouths near the coast.

DESCRIPTION OF THE ENGINES.

The Leeghwater Engine, as shown in Figs. 1, 2, and 5 of the accompanying Engravings, Plates 1 and 2, has two steam cylinders A and C, one within the other, united to the same bottom X, but the inner one is not attached at the top, a clear space of 1½ inch existing between it and the cover, which serves for both cylinders. The large cylinder A, is 144·37 inches diameter and 1½ inch thick, and C, the small cylinder, 84·25 inches diameter and 1¾ inch thick; both are truly bored out, and the small cylinder is also turned on its outer circumference. B is a steam jacket for the large cylinder, cast in 13 segments—which is again enveloped by a wooden casing *l*, having 4 inches of peat ashes between them.

Pistons.—The small cylinder C is fitted with a plain piston of 5474·81 square inches area, and the large cylinder A is occupied by an annular piston of 10,323·36 square inches area. The areas of the two cylinders, after deducting 472·8 square inches for the thickness of small cylinder, are as 1 to 2·85. The internal and external packings of the pistons consist of hard cast iron segments at bottom, with gasket above, pressed down by glands, also in segments; the open spaces in the pistons *c c* are filled with cast iron plates, and the tops of the pistons have moveable cast iron covers.

Cap or Crosshead.—The pistons are connected to the great cap or crosshead G by the main piston rod Y, of 12 inches diameter, and by four small rods *y* of 4½ inches diameter (figs. 1 and 5). The great cap G has a circular body 9 feet 6 inches diameter, divided into eight compartments, which can be filled with cast iron weights; from its centre a guide spindle *x* passes through a stuffing box placed in the centre of a great beam of timber 2 feet square, which passes across the engine-house, and is secured to its walls; there are two other guide rods, *b*, which pass through stuffing boxes in the arms of the great cap G, and are secured to the upper and lower spring beams.

Plungers.—Suspended from the arms of the great cap are two 9-in. plunger poles F, working in plunger cases D; attached to D are two valve nozzles *d''*, connected with stand pipes *d'*, by two branch pipes *d'''*; the valve nozzles are connected with each other and an hydrostatic equilibrium valve nozzle O, from the bottom of which a branch piece is connected with the stand pipes *d'* by the pipes *d''''*. The exterior surfaces of the plunger cases D, are turned truly, so as to allow the rings *e e* to slide up and down freely; the rings are suspended from the great crosshead by rods *v*, and are furnished with cross bearings, on which the jaws of the two air-pump balance beams E rest: the inner ends of these balance beams move in a perfectly vertical line, and the outer ends are furnished with rollers working between guides, to allow for the variation of the beams during the up or down stroke.

Air Pump.—From the centre of the air-pump balances, the two air-pump plunger pistons *n'* are suspended (fig. 2); diameter of plunger pistons 40 in., stroke 5 feet; the two air-pumps N are united by a branch piece with the bottom of the condenser M. The condenser has an intermittant injection by a valve 8-in. diameter, and a constant injection by another valve of 3-in. diameter. R is the condenser cistern.

Pipes and Valves.—L is the steam pipe (2 feet diameter) from the boilers; in it is placed a double-beat governor valve of 16-in. diameter.

P, the induction valve, 16-in. diameter and nozzle.
Q, Equilibrium valve, 20-in. diameter and nozzle.
S, Eduction valve, 26-in. diameter and nozzle.
q, Equilibrium steam pipe.

The induction and equilibrium nozzles are each connected to a separate port cast in the cylinder's bottom. The eduction nozzle is connected by a pipe M, 34-in. diameter, to the branch-pipe M of the condenser. The pipe M is also connected to the bottom of the cylinder, in which a port is cast, which communicates with the space under the annular piston; by this arrangement a constant vacuum is maintained beneath that piston.

The Hand Gear is connected to the weigh post K, and the plug rod is worked by a lever and shaft T, the outer end of which is slotted and worked by a pin on the sliding ring *e*.

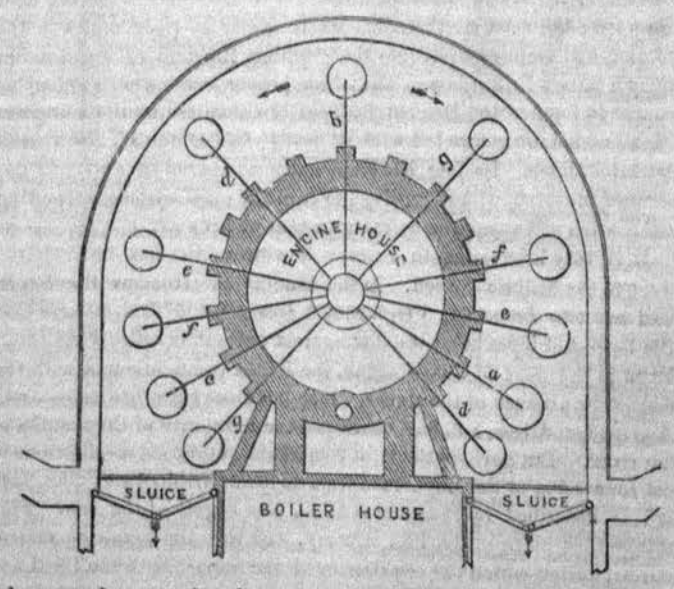
Pumps—The engine works eleven pumps of 63-in. diameter; each pump is furnished with a cast iron balance beam H (fig. 1), which radiates from the centre of the piston rod; the inner and outer arms are of equal lengths from the centre gudgeon. The inner ends of the balance beams are furnished with cast iron rollers, working against a plate, fitted with guides for each roller, which is screwed up against the under-side of the great cap; each beam is connected to the cap by two slotted bridles, to ensure simultaneous upward motion during the up-stroke of the engine. From the outer end of the balance beam the pump piston is suspended by wrought iron rods, 3-in. diameter and 16 feet long, and an additional length of 14 feet of patent chain cable attached to the pump piston. Fig. 3 shows a section of one of the pumps, and fig. 4 an elevation of the piston. A, working barrel, 63-in. diameter; B, windbore and clack piece; C, the piston or bucket; D, bottom valve and seat.

The pump piston C is of a peculiar construction; it is composed of a wrought iron centre piece, 1 inch thick; firmly bolted to this piece are two double elbow frames of cast iron, called "the cradles;" the elbows are faced with gun-metal plates; the cradles serve to support two wrought iron semi-elliptic valves *c c*, which occupy the whole area of the pump when they fall out, and constitute in fact the piston. These valves are edged with wood, having a piece of leather on the upper side secured by a wrought iron gland; the valves are hung to the centre piece at about 3 inches from their lower edges, so that when they open during the down stroke, any dirt or sand which has lodged on the bottom may fall through. Attached to the centre piece are two plates of cast iron, which serve as ballast to sink the piston; these ends are cast with a jaw, in which pieces of wood are secured to prevent friction against the sides of the pump and to give steadiness to the piston. These pistons require a weight of 1·4 lb. per square inch of the area of the pump to sink them with the velocity required upon the down stroke. The pump pistons of the Leeghwater are not furnished with guides, as shown in figs. 3 and 4, and work very well without them: but the pistons for the pumps of the Cruquius and Van Lynden engines (now constructing for the drainage of the lake) will have guides, as shown in the drawings, in consequence of the diameter of the pumps being increased to 73 inches.

Pump Valves.—The bottom valves have cast iron seats secured to the windbore, the valve beats are of wood, and the valves are simply plates of wrought iron, 1 inch thick; the valves are not hung on fixed joints, but are each fixed to a bar, the ends of which are entered in cast iron slot pieces, allowing a rise of 1½ inch, so that the valve can rise altogether from its beat, and give a large water passage all round.

Power of Engines.—The steam and pump pistons both perform a stroke of 10 feet in length: each pump by calculation should deliver 6·02 tons of water per stroke, or 66·22 tons for the eleven pumps; but by actual admeasurement of the quantity delivered, it is found to be 63 tons. The loss might be reduced, but probably at the expense of increased friction.

The Engine House is a massive circular tower, concentric to the cylinders; on its walls are placed the eleven pump balances radiating from its centre, shown in the accompanying sketch. The pump



balances *a*, *b*, *c*, are placed at 120 degrees from each other; *d d*, *e e*, *f f* *g g*, are placed opposite each other: therefore, by this arrangement, the equilibrium of the great cap of the engine, under which the inner ends of all the balances are concentrated, is not in any way disturbed. If any of the pumps require repairs, the opposite pairs can be easily detached, without causing more than a trivial delay to the working of the engine.

The Action of the engine is very simple; the steam being admitted into the small cylinder, the whole of the dead weight and pump balance beams attached to the great crosshead are elevated with it, and the steam being cut off at such portion of the stroke as may be required, the remainder is effected by the momentum acquired by the dead

weight and the pressure of the expanding steam upon the small piston (the pump pistons at the same time make their down stroke); at the end of the up stroke a pause of one or two seconds is requisite, to enable the valves of the pump pistons to fall out, so that upon the down stroke of the steam piston they may take their load of water without shock. During this time it is necessary to sustain the great crosshead and its load of dead weight at the point to which it was elevated by the up stroke, as otherwise it would fall back until the expanded steam under the small piston was compressed to a density equal to the pressure per square inch of the load lifted, or would cause a very violent shock upon the pump valves by suddenly throwing them out against the sides of the pumps. To avoid these evils, the hydraulic apparatus D F was devised.

Hydraulic Apparatus.—When the engine makes its up stroke, the plunger poles F (which form part of the dead weight) are lifted, and the water from the stand pipes and reservoirs d'' flows through the valves d'', and follows up the plunger poles as fast as they are elevated. At the end of the stroke the spherical valves instantly close, and the dead weight is suspended exactly at the point at which it had arrived—and, of course, if the valves are tight, could be maintained there for any given period; in consequence of all strain being thus removed, there is no pressure to close the valves of the pump pistons beyond their own weight; therefore, they fall out without the slightest shock. To make the down stroke, the equilibrium steam valve Q, and the hydraulic valve O are opened *simultaneously:* the water from beneath the plungers escapes to the stand pipes and reservoirs by the pipes d'''', and the steam from the small cylinder passes by the pipe q, round to the upper side of the small and annular pistons, puts the pressure on the small piston in equilibrium, and presses upon the annular piston (beneath which a constant vacuum is maintained), in aid of the dead weight now resting upon the inner ends of the pump balances: by the united effort, the pump pistons are elevated and the water discharged. Before the next stroke is made, the eduction valve is opened and a vacuum formed over both pistons.

So well does the hydraulic apparatus just described, effect the object for which it was designed, that the Haarlem-mer Meer Commissioners have decided to use only eight pumps, but of 73-in. diam., for the other engines; the chief reason for the adoption of the 63-inch pumps for the Leeghwater Engine having been the fear of the shocks to which such large pump pistons are ordinarily liable.

Boilers.—The Leeghwater Engine is furnished with five cylindrical boilers, each 30 feet long and 6 feet diameter, with a central fire tube, 4 feet diameter: a return flue passes under the boilers to the front, and then splits along the sides. Over the boilers is a steam chamber, 4 ft. 6 in. diameter and 42 feet in length, communicating with each boiler; from thence a steam pipe, of 2 feet diameter, conducts the steam to the engine. The steam space in the chamber, boilers, and pipe is nearly 1320 cubic feet, and as the engine draws its supplies from such an immense reservoir of steam, no "primage" takes place, and a very uniform pressure upon the piston is obtained until the induction valve closes. These boilers have produced steam enough to work the engine to the net power of 400 horses. The Cruquius and Van Lynden Engines will have boilers capable of working to 500 horses' power if required.

The Drainage.—Prior to the construction of the engine-house, &c. an earthern dam of a semi-circular form was thrown out into the lake, to enclose about 1½ acres; after the water was pumped out from within the dam, a strong piled foundation was made, and the masonry commenced at the depth of 21 feet below the surface of the lake: a small steam engine was erected to evacuate the water from the dam. When the Leeghwater was completed, the Commissioners determined to test its merits fully before deciding on the construction of the other engines upon the same model; and as they had the means of evacuating the water within the dam to any level required, the Leeghwater could be tried and worked continuously under any circumstances, precisely similar to those which will occur during the drainage of the lake, if, instead of discharging the water from the pumps into the upper canal, it was allowed to fall back again to the level from whence it was derived.

The average depth of the lake is 13 feet below the general level of the surface water of the canal and watercourses conducting to the sea sluices; when the communications between those waters and the lake are closed, the engine will at first have only the head of water caused by the discharge from the pumps, and the friction of the machinery, to overcome; in this state, all the filling plates or ballast of the great cap and pistons will be taken out, and counter-balances added to the pump balance beams "out of doors," so as to take up as much of the dead weight attached to the great cap as may not be required for working the engine: as the lift becomes greater, the dead weight "in doors" will be gradually added. In this manner, the engine was worked for a considerable time, to get all the parts in good working order. A sub-committee of the Commission conducted a series of experiments, and satisfied themselves that the Leeghwater will perform a duty of 75 million pounds, lifted one foot high, by the consumption of 94 lb. of good Welsh coal, whilst exerting a net effective force of 350 horses' power. With a lift of 13 feet, the engine easily worked the eleven pumps simultaneously; the net load of water lifted being 81·7 tons, and the discharge 63 tons, per stroke.

When the bed of the lake is cultivated, the surface of the water in the drains will be kept at 18 inches below the general level of the bottom; but in time of winter floods, the waters of the upper level of the country will be raised above their ordinary height: in which case, to keep the bed of the lake drained to the regulated height, the lift and head may be increased to 17 feet. To test the power of the engine under these circumstances (and without regard to the consumption of fuel), the whole of the 11 pumps were worked simultaneously, and the extraordinary quantity of 109 tons net of water was raised per stroke to the height of 10 feet; but, in practice, it will be advisable to work a less number of pumps, and increase the number of strokes per minute.

After numerous and severe trials of the engine, the Commissioners were satisfied that it is capable of performing its work under the most difficult circumstances that can arise; and immediately determined on having two more engines constructed, of equal size, and on the same model—the only material alteration being in the arrangement of the pumps; the number being reduced to 8 for each engine, but of 73 in. diameter, placed in pairs opposite each other, and the ends of the balance beams projecting over the great cap of the engine (instead of under as in the Leeghwater), to which they will be connected by stout wrought-iron straps. The boilers also will be increased in number, and in power nearly 100 horses. All the feed-water will be filtered before passing into the boilers.

Advantages of Two Cylinders.—Many persons imagine that the engines are constructed with two cylinders to obtain a greater expansion of the steam than would be attainable in one cylinder; but such is not the case, as no greater economy of steam can be obtained by the use of two cylinders than by one, although greater steadiness of motion for rotatory engines, and less strain upon the pitwork of a mine-pumping engine, may result from the use of two cylinders. In the Haarlem engines two cylinders are used, because if one cylinder only were employed it would sometimes be necessary to use a dead weight of 125 tons to overcome the resistance of the water load and friction of the engine and pumps; such a mass of iron or other heavy material would be unmanageable, and no alteration in the force of the engine could be effected but by taking from or adding to the dead weight, which would be a source of great difficulty and inconvenience, when the varying character of the load, during the drainage of the lake, is considered; particularly as at times the water will be charged with so much foreign matter as greatly to add to the friction of the pumps. By the system adopted the maximum dead-weight elevated by the small piston will seldom exceed 85 tons; the additional power required being derived from the pressure of the return steam, at the down stroke, on the annular piston; by varying the expansion and pressure of the steam in the small cylinder, the engineman can add to, or diminish the pressure upon the annular piston, so as to meet any case of variable resistance without the inconvenience and delay attending an alteration of the dead weight; the load is therefore under perfect command at all times.

Quantity of Water.—The area of the Haarlem Lake is 45,230 acres, the estimated contents to be pumped out about 800 million tons, but should the quantity be increased by any unforeseen cause even to 1000 million tons, the whole amount could be evacuated by the three engines in about 400 days.

The bed of the lake when drained must be always kept dry by machinery, and observations continued during 91 years show that the greatest quantity of rain which fell upon the area of the lake in that period would give 36 million tons as the maximum quantity of water to be elevated by the engines in one month; to perform this work would require a force of 1084 horses' power to be exerted during that period; the average annual drainage is estimated at 54 million tons.

The cost of the Leeghwater, buildings, and machinery was 36,000*l.*; of this amount about 15,000*l.* are due to the buildings, and certain contingencies. For the foundations 1400 piles were driven to the depth of 40 feet into a bed of hard sand, and a strong platform laid thereon at the depth of 21 feet below the surface of the lake; upon this platform at the distance of 22 feet from the engine-house, a strong wall pierced with arches was constructed, and at 7 feet from the coping, a stout floor of oak was laid between the wall and the engine-

house; the pumps rest upon the platform beneath and opposite the arches, and their heads come through the floor alluded to, and stand about 3 feet above its level: into the canal thus formed between the engine-house and the outer wall, the water from the pumps is discharged, and flows off on either side of the boiler house, through sluice gates, into the canals conducting to the sea sluices.

The great cost of the buildings for whatever description of machinery might have been employed, rendered it an object of considerable importance to lessen this expense by concentrating the power to drain the lake in three engines; in addition to which a considerable saving in the wages of enginemen, stokers, and others is effected, as these large engines require very little more attendance than an ordinary mine engine; this is an important feature in the economy of the charge for the permanent drainage of the "Polder," which will be formed by the bed of the lake.

The average consumption of the ordinary land-draining engines applied to scoop wheels and Archimedean screws, may be taken at 15 lb. of coal per *net horse power* per hour; this quantity will be greatly reduced if the horses power of the engines be calculated by the pressure of the steam on the pistons, and not by the net delivery of the water; in a case where the water delivered by a large steam engine working a scoop wheel, was measured during eight hours, the engine was found to exert a *net* force of 73 horses' power during the first hour, with a consumption of 15 lb. of coals per *net* horse power; as the lift increased the power diminished, and the consumption of fuel increased, until at the eighth hour it was found that the engine only exerted a *net* force of 33 horses' power, and consumed 24 lb. of coal per *net* horse power per hour. The consumption of fuel by the Leeghwater is 2½ lb. of coals per horse power per hour when working with a net effective power of 350 horses.

No *new principle* has been developed in the Leeghwater, but important facts have been demonstrated, which must have an immense influence on the progress of agricultural hydraulic engineering: it has proved that with proper attention to well-known principles, steam engines of the very largest class (the Leeghwater is believed to be the largest and most powerful land-engine ever constructed), may be employed to raise great bodies of water from low lifts for the drainage or irrigation of low lands with as great an economy of fuel as was hitherto generally supposed to be confined to the elevation of comparatively small quantities of water to great heights. To the Haarlem-mer Meer Commissioners belongs the merit of having ventured to carry out this bold experiment, and they will reap their reward by an economy of at least 100,000*l.* over the cost of draining the lake by the ordinary system of steam engines and hydraulic machinery employed to drain land; and of upwards of 170,000*l.* and three years time, over the cost of draining the lake by the windmill system hitherto generally employed in Holland.

Upon the cost of annual drainage an important saving will also be effected; by the system adopted it is estimated at 4500*l.*, by windmills at 6100*l.*, and by the ordinary steam engines at 10,000*l.* per annum, and if interest at 5 per cent. on the money saved in the original cost of draining the lake be taken into the account, the figures would stand thus, 4,500*l.*, 14,600*l.*, and 15,000*l.*

The Leeghwater is named in honour of a celebrated Dutch engineer, who, from his great success in draining numerous lakes in North Holland, was popularly known by the name of "Leeghwater," or "the drier-up of water," and with him the first proposal to drain the lake originated in 1623. The other two engines are called Cruquius and Van Lynden, after two celebrated men who have at various periods interested themselves in promoting the drainage of the Lake.

The engines and pumps are manufactured at the well-known establishment of Messrs. Harvey and Co., of Hayle, and Messrs. Fox and Co., of Perran, Cornwall; the pump balances and boilers by Messrs. Van Vlessingen and Van Heel, of Amsterdam.

TRABEATE AND ARCUATE ARCHITECTURE.

THIRD ARTICLE.

It is but a thankless office to demonstrate that an object of general admiration is unworthy of the homage paid to it: though the innovator may dethrone the idol, he cannot propitiate its worshippers. The advocate of heterodox opinions in architecture must not, therefore, even if he succeed in convincing his opponents, expect to win their applause. In these papers, of which the object has been to demonstrate the errors which have crept into our architectural system from an attempt to combine two irreconcileable means of construction—the arch and architrave—we have endeavoured to avoid the appearance of heterodoxy by confirming our opinions by the citation of acknowledged authorities. For the last three centuries it has been customary to consider architectural forms independently of their purpose; but though the effort to inculcate similar principles be comparatively recent, the labourers in this arduous undertaking are by no means few. We already reckon the names of Hope, Willis, Whewell, Cockerell, and Paley, among the advocates of architectural truth.

As an example of the effects of confounding trabeate and arcuate architecture, we have referred to the inconstructive arrangements of the dome and other parts of St. Paul's Cathedral—a bold illustration certainly, but one supported by the recorded opinion of Professor Cockerell, that this building exhibits a confusion of the principles of Classic and Christian Architecture. If, by way of contrast with the dome of St. Paul's, we examine the spires of Chichester or Salisbury Cathedrals, the difference between the principles of the mediæval architects and of those who succeeded them will be set in a very clear light. In the two mediæval spires there is no casing or outer covering to conceal the inner mechanical arrangements of the structure. Every course of stones used in the construction is visible, both from the outside and inside of those noble works. The visitor on ascending finds himself within a vast cone, formed of circular horizontal courses of masonry, diminishing in diameter from the base to the summit: he looks in vain for a single means of support not visible from the exterior of the cathedral. In St. Paul's, on the contrary, the *real* spire is, as has been shown, a concealed cone of bricks: the dome is merely a wooden frame-work fixed on to the cone after it was finished. Two ends are answered by this contrivance: the bricks are hidden, and an appearance of vaulting is given where it does not exist.

This and similar inconstructive arrangements are readily explained when we consider them the natural effects of an attempt to combine arch and architrave construction. It is time however to turn to another example of those effects; and the inference with respect to modern art being far more direct in the instance which we are about to select than in the former, the necessity of quoting authorities becomes greater.

"But of all the parts borrowed from Grecian Architecture," says Hope in the eighth chapter of his admirable Essay, "that which came to be applied in the way most different from, most inconsistent with, its nature and distinction in the original, was the fastigium, the part which we call the pediment.

"The pediment, which was only the termination of a roof slanting both ways from its central line or spine, of which, throughout its whole length, from end to end, the continuity was never broken, which was never seen in Grecian buildings, except on the straight line at the summit and the gable formed by the extremity of the roof, in Roman architecture frequently appeared as if cut off from all that belonged to it, and grew out of, and was stuck under, the entablature which it should have surmounted, against the upright wall, or a window, or a niche,—even as in the temple of Balbeck, placed within a projecting portico, a situation in which it could not be useful even to carry off the wet. . . . . In Grecian architecture the square pilaster only terminated the square pier or antæ; by the Romans it was carried in shallow slips or slices along the whole surface of the wall; and as the tyrant Maxentius tied together the living and the dead, so the architects of Rome everywhere attached the round, vigorous, and independent column to one of these flat, weak, and confined pilasters, for no other purpose that can be conjectured than that the effect of its tapering form might be destroyed by the straight lines of the pilaster."

These opinions respecting the use and abuse of pediments and columns are applied, in another part of the same work, to the Cathedral of St. Peter's, at Rome, in the following terms:—"One condemns in the church its front so much broken by partial projections, its pediment standing on a base too narrow, and an expanse too small, and *rendered evidently useless by the ponderous attic that rises behind it* and crushes the façade to which it was intended to give elevation.

"Contemplating those columns of nearly 9 feet in diameter, but which, formed of masonry of small stones, only look on a near approach like small turrets, one cannot help casting a lingering look back on the portico of the Pantheon, and thinking that elevation of insulated columns of granite of one single piece, though smaller in its dimensions, grander in its conception, and more striking in effect, than these clusters of large pillars, all reticulated with joints, and jammed up against a wall."

All these solecisms in the employment of pediments and columns may be easily traced to the attempts to retain the *forms* of Greek trabeate architecture, after the invention of the arch. By means of this invention the Romans were enabled to give to their edifices an extent and diversity of form before unknown. It was no longer necessary for the stability of a structure, that its roofs should be supported directly from the ground by vertical columns, placed so close that the intercolumniation might be spanned by a single block of stone. On the contrary, the buildings were raised to many stories in height, and both vertically and laterally were made up of that vast multiplicity of parts which, judging by the eye alone, we should pronounce the main *formal* distinction of Roman from simple Greek architecture. A natural consequence of the invention of the arch was the vaulting of roofs, which rendered the pediment generally unnecessary, and therefore adscititious.

It is by no means to be inferred that the introduction of the arch was prejudicial to the art. On the contrary, every new contrivance by which construction is facilitated ought to be looked upon as a direct benefit to architecture; for the most liberal and elevated views of an art are those which encourage its extension by every available means. The injurious effects complained of by Hope arose, not from the invention of the arch abstractedly considered, but from the injudicious application of it. It had rendered almost all the Greek forms unnecessary; they ought therefore to have been unreservedly abandoned in arcuate building, or at least those of them alone should have been retained which were necessarily common to the two modes of construction.

The pediment was appropriate and had meaning where what Hope aptly terms the *spine* of the roof (that is, the line formed by the two inclined planes intersecting at their vertical angle) was continued throughout the building from end to end. Where, however, the roof was flat, or surmounted by a horizontal entablature, as in Roman, and subsequently in Lombardic, architecture, or where the structure was crowned by a "ponderous attic," as in the case of St. Peter's, and numerous modern English buildings to which it is unnecessary to specify, it is clear that the pediment could have no real constructive use.

To the general reader we may appear unnecessarily minute in insisting upon these points, because he is not aware how much prejudice has to be surmounted in establishing them. A great change of opinion on architectural subjects is, however, happily taking place, and we trust that the day is not far distant when these observations will appear superfluous arguments in favour of self-evident propositions. For the present, however, we must be content to utter truisms, and to illustrate in every possible way their application and effect.

Flat-roofed buildings can never require pediments: let us apply this rule to the new show-front of the British Museum, now nearly completed. We will at once allow that there is something exceedingly attractive in the long range of numerous columns there presented to the eye. Columniation on an extensive scale has such peculiar magnificence that the difficulty is rather to produce an ungraceful, than a graceful, appearance by means of it. The architect of the British Museum has, however, surmounted this difficulty to a great extent. Still, much remains that will captivate the general eye, and we doubt not that those who prefer profusion of ornament to the right use of it, will greatly admire the new façade. But we are now addressing those who are willing to estimate architecture not by the eye alone, but by the judgment also.

It is to be observed then, in the first place, that the British Museum, though an isolated structure, in a position where it is seen from many points of view, has only one side decorated, the decorations being of course placed where they will be seen from the most frequented street.

"Purpureus, late qui splendet, unus et alter
Assuitur pannus."

The pediment, consistently enough, is stuck on to the façade, just as the façade is stuck on to the building. The horizontal entablatures of the wings are either mere masks to conceal the real outline of the roofs, or else the roofs are flat. On the latter supposition, it is quite clear that the central pediment is placed where it does not define the outline of another roof; for a glance will convince us that there is not behind this pediment an inclined roof with its axis perpendicular to the front of the building, and its spine continued "throughout the whole length from end to end."

In point of fact, this pediment has no more connection with the building than the sign-boards frequently seen on the parapets of taverns have with walls to which they are attached. The comparison may be a homely one, but it exactly expresses the nature of the case Similar remarks might be applied to the Mansion House, Buckingham Palace, and numerous other buildings, in and out of London; but the general principle is so clear, that it is useless to provoke unnecessary opposition by pointing out all its consequences.

Had not custom familiarised us with the absurdity, there would appear something inexpressibly ludicrous in the fashion of uniting the front of a Greek temple to a modern secular square-built structure.

It is well known that a systematic and growing opposition to Classic architecture now exists in this country. Those who resist the novel tenets and express their indignation at the term "Pagan," do not consider that they themselves strengthen the arguments of their opponents by their adherence to debased Classic architecture. A barbarous confusion of different principles of construction can never be permanent, however obstinately it may be defended; and it certainly appears the most prudent course to give up a part of the contest at once, and return to pure and faithful Classic architecture, than, by blindly defending its most corrupt forms, to ensure the ultimate disuse of every form of it.

The attempt to combine the forms of trabeate and arcuate construction has produced, as all will admit who are not interested in the denial, a strange mongrel style, in which members, which had originally significance and utility, are distorted and disarranged in every conceivable manner. Such architecture resembles a mere *hortus siccus*, or herbal filled with botanical specimens; for its relation to true architecture is that of withered leaves to a living flora. Or is it not, rather, an architectural Frankenstein, endued with vitality indeed—but vitality of that monstrous kind which renders it only the more hideous by adapting its individual members to strange, unnatural uses?

REMOVAL OF WESTMINSTER BRIDGE.

Many arguments have been urged in favour of the existing site of Westminster Bridge; those in favour of a new site have not yet been communicated to the public. There can be no doubt that the Commissioners of Woods and Forests have wise and cogent reasons for giving notice of their intention to apply for "an act to alter, amend and repeal, several acts of Parliament passed during the reigns of George II. and III., relative to Westminster Bridge, &c." And as we give the Commissioners credit for the best and most prudent motives, it cannot but be regretted that the public have of late years fallen into the unhappy habit of judging for themselves on matters of public interest. It has been argued (indiscreetly, no doubt) that the collective opinion of the inhabitants of Westminster and Lambeth as to the relative advantages of the new and old sites, is as valuable as that of a Government commission. The idea that the latter possess exclusive information on the subject, and are therefore the most com-

petent to decide, is summarily rejected by the contending party, who reply (and it is difficult to detect a flaw in their reasoning) that the nature of the subject precludes the existence of exclusive information—that whatever knowledge of the facts may be possessed by the Commissioners is shared with the inhabitants of the districts affected—that the convenience of any particular thoroughfare is to the latter a matter of daily observation, and that in the ordinary intercourse of trade they would be certain to learn whether traffic was obstructed by difficulties in the route chosen for it. Finally, it is argued that if the Commission *have* any exclusive knowledge on the subject, it is the very kind of a knowledge which they ought not to have; for though private information may be very important in carrying on business of high diplomatic importance, the existence of private information on such a very matter-of-fact topic as the alteration of a thoroughfare gives colour, at least, to a charge of undue regard for private interests.

At a crowded meeting of the inhabitants of Westminster, held during the last month, the chairman, Mr. B. Hawes, the member for Lambeth, in opening the proceedings, said—

"There had been no manifestation of public feeling in favour of the proposed new bridge to Charing-cross, although the money for erecting it, amounting to upwards of £2,000,000, would be taken from the public purse. The new bridge had not been sanctioned by the goverment, further than that a public department had consented to give certain notices prior to the introduction of the bill. He hardly thought any member for Lambeth, Westminster, or Surrey would be found to support such a measure; and it might reasonably be asked what public reason was to be assigned for it? He understood the architect of the new Houses of Parliament thought the present bridge an eye-sore; but could it not be repaired and beautified, or rebuilt on the existing site? There were many reasons for retaining it: first of all, on the ground of economy. All the approaches to the present bridge were the property of the bridge commissioners. In the next place, a bridge lower down, as was proposed, must be longer and larger, and all the approaches would have to be bought. But was it just to existing interests to build a bridge elsewhere? There were at present two private bridges close to the site of the new bridge—Waterloo and Hungerford bridges—the first of which did not pay a farthing to the subscribers, and the other paid but very badly. From the proposed bridge to Waterloo-bridge there would be a distance of only about 200 feet, whilst the Hungerford-bridge would be close to it; and Westminster-bridge being taken down, there would be no accommodation for the public from the Charing-cross bridge to Vauxhall bridge—a distance of about a mile. When the present bridge was built, the site was a matter of considerable discussion; it was, moreover, selected as the most beneficial for the public at large; and he believed, that from the corner of York-road over the new bridge to Charing-cross, would not be 20 yards nearer than by the present route. Besides this, there was a great traffic westward over Westminster Bridge to Belgrave-square, Pimlico, Knightsbridge, &c., and access to the Houses of Parliament, and the law courts. He pledged himself to oppose the bill in every stage, and he did not believe that five gentlemen would be found in parliament to sanction such an unnecessary waste of public money."

It was also asserted at the meeting, that the Commissioners themselves were not very strongly persuaded of the necessity of altering the situation of the bridge, but had merely *allowed* their solicitor to prepare the notices: another suggestion was, that Hungerford Bridge had been already conditionally sold to the Southampton Railway Company, who intended to use it as an approach to their new terminus in Lambeth. If this important information be correct, it may reasonably be feared that the promoters of the removal of Westminster Bridge to Charing-cross will incur the charge of over anxiety to facilitate the conversion of Hungerford Bridge to the purposes of the Southampton Railway Company. This bridge and the new Westminster Bridge would so nearly adjoin at their Lambeth ends, that the former would be rendered nearly useless to the public at large; and its conversion would therefore be greatly facilitated.

The metropolitan bridges are at present nearly equidistant. This arrangement secures the greatest amount of benefit from each of them: but by removing Westminster Bridge to Whitehall-place, a large and densely-populated district, extending from that point to Vauxhall Bridge, will have no intermediate communication with the opposite bank of the river. There can be no doubt but that after a time, this evil will be so seriously felt, that another bridge must be built above the new Houses of Parliament—that is, the public will be put to the expense of building two bridges instead of one. Moreover, may we not justly complain of the inconsistency of pronouncing Hungerford Bridge by one legislative act a useful, by another a useless, structure? The only just ground for sanctioning its erection was public convenience. If it were not of public utility it ought not to have been erected: if it were of public utility it ought not to be rendered useless, by the erection of another bridge almost close to it. In every point of view, the proposed measures present the same appearance of being anticipatory of a purchase of Hungerford Bridge for private purposes. For no one would be mad enough to propose two contiguous bridges, unless one of them were about to be closed against the public.

We have said little of the injury to existing and justly acquired interests consequent on the alteration, because we wish to view the question on general grounds. But it certainly seems a matter of injustice, almost of robbery, to ruin the property adjacent to the present line of traffic. Many of the houses in the roads leading to Westminster Bridge have, doubtless, frequently changed hands during the last century, and the price of purchase must have beeu materially influenced by the consideration of the present facilities of communication. The purchaser, who has bought on faith of the permanence of those facilities, finds suddenly that the amount of his purchase-money was twice too much. On the other hand, the owner of mean tenements in Lambeth, adjacent to the new site of the bridge, finds himself in possession of valuable property, at a most inadequate cost. The injustice is double. The latter class of purchasers have no moral right to a treble or quadruple value of their property—the former class are deprived of the value of investments honestly and legally acquired.

To the lover of architecture, it will appear no small argument against the removal of Westminster Bridge, that by that act the only convenient point for viewing the Houses of Parliament is lost to the great body of the inhabitants of London. This consideration has gained additional force since the repairs of the old bridge have been in progress. Recently, the footway has been lowered, and a light parapet of wood, breast high, has been substituted for the former lofty balustrade, by which the view was almost entirely obstructed. The river facade of the New Palace, consequently, presents itself to the eye with a distinctness and unity never before exhibited. It is really curious to observe how much the appearance of the edifice has been improved by the alteration of the bridge. Of course, this advantage would be sacrificed by removing the bridge to Whitehall-place; in fact, the public generally would then have *no* means of viewing the Palace of Westminster except from a considerable distance. That Mr. Barry has nothing to do with the proposition for altering the site of the bridge, but is, on the contrary, desirous that it should remain unaltered, may be announced on the authority of a statement made by Mr. Grissell at the meeting referred to above.

THE WELLINGTON STATUE,

AND THE ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Little has been hitherto said in these pages respecting the position of the equestrian statue on the Triumphal Arch in Piccadilly. Our contemporaries have entered upon the discussion so copiously, that room scarcely seems left for new opinions. Besides, when many speakers harangue simultaneously, they are apt to drown each other's voices, and the heat of a debate is but a poor compensation for the lack of judgment and perspicuity. At the present moment, however, as the storm of discussion is somewhat lulled, we may as well profit by the momentary silence to express the few remarks which we have to offer on the subject.

There are many persons of good taste who, without hypercriticism, would condemn a colossal statue in which the natural proportions are greatly exceeded, as a gross unwieldy object, evincing an utter disregard of the modesty of nature. Without, however, allowing the ob-

jection to apply with full force in the present instance, we may still concede that an equestrian figure, exaggerated to gigantic (or more than heroic) dimensions, must require more than ordinary skill in its artistic treatment, and more than ordinary care to render the unnatural magnitude inoffensive. Our visual ideas are all relative. The giants of Brobdignag appeared to Gulliver hideous, and his own size seemed horrible to the Lilliputians.

The Wellington statue will, it is said, be removed to the space between the Horse Guards and the Enclosure in St. James's Park. This removal is on many accounts commendable. A colossal figure, to appear even tolerable, must be placed where the disparity of surrounding objects is not offensively observable. Such a contrast is by every means to be avoided, and the eye must be attracted by the absolute, not by the comparative magnitude of the work of art. Colossal figures have generally appeared best when standing on a wide open plain, isolated from all other artificial objects. The Lion on the field of Waterloo is so placed, standing apart from human habitation, on a broad expanse of country, over which it is visible for miles round. The appearance of the figure in such a situation is, we imagine—for we have never seen it except at a great distance—very effective. The size of the object accords well with its solitude and its simple character.

By analogy, we may presume that this new memorial of the Waterloo conflict should be similarly isolated. To find in London a situation which would perfectly fulfil the conditions here suggested, is of course impracticable, but the position in St. James's Park sufficiently satisfies them. Elevated on a simple plinth or base of steps, at a considerable distance from the nearest building, the statue would no longer look a heavy lump of metal; its size would, we may hope, appear magnificent —at present it seems merely unnatural.

The circumstance of the statue being initially placed in its present ridiculous position will prove by no means prejudicial to the interests of art. On the contrary, the discussion which has arisen produces this net result—the English people will no longer tolerate the absurdity of statues elevated out of sight. The condemnation of the present position of the Wellington Statue, and the ridicule heaped on the Nelson Monument, will render the renewal of this kind of barbarism practically impossible. One great step has therefore been taken in the progress of the doctrine of truth and fidelity in art. The grand objection to the position of the Nelson and Wellington statues is, that their merits or defects as works of art are inappreciable to the ordinary powers of vision. The whole matter may be reduced to a dilemma: if the statues be worth seeing, they should be put where they can be examined; if the statues be not worth seeing, they ought not to be erected as public monuments.

As far as can be at present judged of the Wellington Statue, it is not unworthy of being publicly exhibited. It would be unwise to anticipate the opinion which will be formed of the statue when situated more conveniently for examination; but to judge from the outline (which is almost all that is now discernible), the composition, if not possessed of extraordinary merit, is free from gross defects: and it is stated that the work has been carefully finished and will bear a near inspection. The new pedestal ought to be very simple and of ample breadth, and its elevation ought to be regulated by this plain rule—the best height to which a statue can be raised is that at which it can be most conveniently examined. We have strong hopes that on such a pedestal, and in such a commanding situation, the monument will not prove unworthy of the events commemorated.

The opinion of the Institute of British Architects respecting the elevation of the statue on the arch, corroborates the judgment already formed by the public. The Report of the Institute is already before our readers, and is worth a brief analysis; it consists of six paragraphs, of which three are argumentative. The three reasons for which the Institute condemns the position of the statue are these—first, because Mr. Burton does not like it; secondly, because it injures the architecture of the adjacent buildings (among which are Apsley House and the "elegant" screen next to it); thirdly, because it is an innovation.

We should like to know which of these arguments satisfies the reader: neither has much weight with ourselves. We do not fear that the merits of Mr. Burton's arch will be destroyed, because we are unable to perceive their existence: and the same consideration removes all apprehension respecting Apsley House and the row of stone columns adjacent to it. In the first place, the triumphal arch displays eminently the fault of all its tribe—forms without purpose. If the arch be *real*, its object must be to support a superstructure of proportional size; a vault so enormous as this would never have been erected without such a superstructure, had the least idea of constructive propriety entered the mind of the architect. The vast arches which form the portico beneath the Victoria Tower of the Houses of Parliament are about as large as that in Piccadilly, but then they are of a size corresponding to their purpose;—were it not intended to support a vast tower upon them, they must appear ridiculous. It seems to be forgotten that an arch is not an integral building, but only a part of one, just as a single limb is only one of the component parts of the animal body. Again, if Mr. Burton's arch were real, it would have buttresses; for we know by ordinary mechanical principles that an arch cannot exist without lateral pressures, and that a buttress diminishing in breadth from its base upwards is the proper form for resisting those pressures. The fact, then, of the buttresses being dispensed with, proves that this arch is applied to no purpose, or to a wrong purpose. Lastly, if the arch were real, what is the purpose of the Corinthian columns and horizontal entablature? An arch properly built requires neither. If the weight be supported on a single beam of stone laid on vertical props (as the columns and entablature suggest), then the arch is superfluous. Or if the construction be altogether different—if the space be spanned by numerous wedge-shaped stones, arranged in the form of a vault—then the columns are superfluous. The arch and the entablature cannot *both* be wanted; one at least of them is inconstructive: we believe that both are.

Neither is Apsley House much likely to be injured. In our view, the columns, stuck in front of the walls of the first floor for show, effectually put the building beyond the pale of criticism. We should have thought the same of the adjacent screen of columns, had not the Institute of British Architects pronounced it "elegant." Where is the elegance? We can see the beauty of the periptery of a Greek temple, for there the columns have meaning and purpose. But surely the row of columns at the entrance of the Hyde Park are *un*-meaning. They sustain no weight but that of the small horizontal course of stones laid athwart them. Judging from their dimensions, you would say that the architect had intended to build a large solid edifice, but had been compelled to relinquish his work when only just commenced: or it might be thought that the substructure was begun by one architect; and that another, who did not know for what superstructure it was intended, had finished it in the readiest way he could.

Amphora cœpit
Institui: currente rota cur urceus exit?

In the second paragraph of the Report, the Institute speak of the triumphal arch as "a successful work:" in the concluding paragraph it is recommended that it should be enriched with "accessorial and subordinate" decorations, as "it would then no longer be subject to the severe criticism of artists, foreign visitors, and persons of acknowledged taste." When the writer of the Report praises the arch as successful, he contradicts the laws of good architecture and common sense; but when he suggests means of avoiding the severe and general criticism of it, he does something totally different—he contradicts himself. We are told, first, that the arch is successful; secondly, that it should be decorated in a very different way to what it has ever yet been, in order to be "no longer subject" to universal condemnation. Clearly then, its success has been of a very different kind to that which the Institute set out by assigning to it.

These strictures upon the Report of the Institute are dictated by a sincere conviction that the formal opinion of so distinguished a body ought to possess far greater weight and authority than will be assigned to this document. The Institute is comprised of those whose learning and position command general respect, and whose zeal in the cause of architecture, and success in the practise of it, indisputably entitle

them to the support of the profession which they represent. But dissatisfaction at the acts of the collective body is not inconsistent with a most ample acknowledgment of the talents of the individual members.

Considering that the leading architectural doctrine of this Journal is the dependance of decoration on construction, it is natural enough that when the Institute applaud structures in which this great principle is grossly violated, we at least should examine the grounds of their judgment. How has it been arrived at? Certainly not in ignorance of the principle of architectural truth. Neither, we suppose, in defiance of it, for this—to put the question on its lowest basis—would indicate opposition to the doctrines advocated by the most learned architectural writers of our own day, and exemplified by the noblest monuments of ancient architecture. No other supposition remains but that the Institute recognise the principle, but are literally afraid of its consequences. Much opposition, doubtless, must be overcome before what may be called *nonsense architecture* is consigned to its deserved destiny. But the Institute carry their complaisance and caution too far when, to avoid offending individual prejudices, they advocate an irrational system which is fast growing obsolete. It lies in their power to contribute most effectually to the emancipation of art from the artifice and conventionalism which have too long enthralled it. They may direct the reform, and beneficially modify its operations; but it is beyond their power to restrain its progress.

Every paper read before this learned body, or sanctioned by it, is retrospective—none prospective. The progression, the improvement of art is scarcely ever heard of. The past—the past only, claims all attention; and this among those who are best qualified to make provision for the future. The Institute owe it to themselves, and owe it to the public, to take a far more elevated and independent position than they have yet assumed: when they have shown their determination to lead the public taste, instead of following it, we doubt not that their title to do so will be universally recognised.

A statement has been made that Mr. Weale offered to the Institute to publish illustrations of the works of the members, and that his offer was rejected. We are in no way concerned in this statement, and know nothing whatever of it but that it appears in the *Westminster Review*, and has been contradicted at a meeting of the Institute. But the very existence of the rumour, and the earnestness of the denial, indicate its importance. The difficulties of procuring information respecting the progress of architecture are, as we know by experience, almost insuperable. Have we not a right to complain that this information is not voluntarily offered? Our applications to individual architects have been met with uniform courtesy and liberality. But we still feel that the *greatest possible* benefit which the Institute could confer on their art would be by calling on the members to detail, from time to time, the progress of their works*—not to read dissertations on Roman remains in London, or the *scamilli impares* of Vitruvius. We are also perfectly certain that this feeling is strongly participated in by the architectural profession at large and the whole body of the lovers of architecture. Surely an opinion so universal ought to claim some respect from the Institute.

To the remarks made at the meeting just referred to respecting the impropriety of authors reviewing their own writings, we fully assent. All public confidence in reviews must cease when the slightest objection or even suspicion of partiality attaches to them. It has been an invariable rule of this Journal that every paper should be rejected, whatever might be the subject of it, if it seemed written with a covert purpose of furthering individual interests. We are quite willing, or rather, we are most solicitous, that if cases should occur in which our subscribers think that this rule has not been applied with sufficient stringency, the particulars should be publicly communicated in our own pages. These observations have somewhat of personal interest; but the occasion seemed to demand them.

* As at the Institution of Civil Engineers.

ON THE INFLUENCE OF HEAT UPON THE COHESION OF LIQUIDS.

By C. Brumner, Jun.

(Translated in an abridged form by M. Rosenthal, M.D.)

Laplace and Poisson have established it as a law, that at various temperatures the height of the capillary column is in a direct ratio with its density. In asserting this, however, they were solely guided by theoretical views on the "force moléculaire." Guy-Lussac's experiments bearing on the above are too insufficient in number to settle the question; and, notwithstanding many valuable publications being since communicated by several authors, Brumner deemed it worthy his consideration to undertake a fresh investigation of the matter. M. Hagen having lately stated that in the case of water, a change of temperature, amounting to a certain number of degrees, has no influence on the phenomena of its capillarity, the author was the more attentive to this point in his researches. M. Hagen in his experiments employed brass plates, brought together in a parallel direction, but Brumner operated with capillary tubes.

These experiments were conducted in the following manner:—The liquid to be examined was introduced into a cylindrical jar, and the latter put in an oil-bath; care being taken that the portion of liquid contained in the capillary tube should be of the same temperature as that observed in the external liquid. To measure the height of the liquid column raised, a glass mass was first immersed in the external liquid, in order to raise the liquid surface until it reached the point of a steel needle fixed for this purpose. The observer, by means of a cathetometer, having noticed the uppermost point of the liquid column raised in the capillary tube, removed again the glass mass immersed as above; the water thus lowered ceased to touch the steel point, and the cathetometer was directed towards the steel point.

The distance between the highest point of the capillary column and the steel point, obtained by means of the cathetometer, indicated the amount of elevation occurring in the capillary tube above the natural level.

These experiments were made with water, ether, and olive oil. In all these liquids, it appeared, the height of the capillary column was considerably diminished by an increase of temperature, in a ratio far greater than would answer to Laplace or Poisson's law relative to the proportionality of density; water, for instance, its temperature being raised from 32° to 158° F., had its density lowered by $\frac{1}{50}$, whereas its capillary height decreased to almost $\frac{1}{6}$. It seems in general that the diminution of the capillary height, caused by elevation of temperature, is *not proportional to density*, but that it is rather corresponding with the *increase of temperature*.

Founded on this assertion, Brumner calculated his experiments agreeably to the method of the "least squares." In this manner he had this law fully confirmed; and the height (h) at which a column of liquid in a capillary tube of one milimeter radius, at a given temperature, is raised, may be determined by means of the following most simple formulæ:—

For water, $h = 15{\cdot}53215 - 0{\cdot}028639\ t.$
For ether, $h = 5{\cdot}3536 - 0{\cdot}028012\ t.$
For olive oil, $h = 7{\cdot}4640 - 0{\cdot}010486\ t.$

In these formulæ, t expresses the temperature in degrees of the centigrade scale.

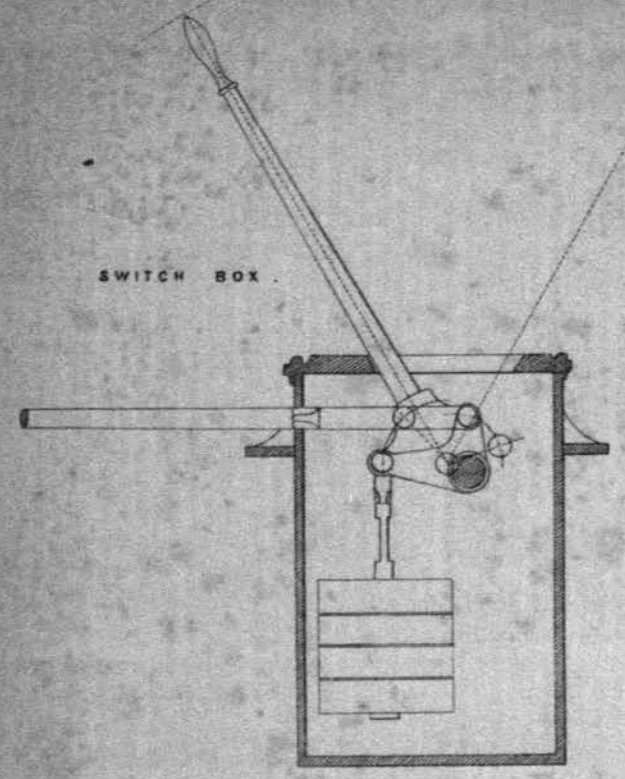
The law, that capillarity is not a direct ratio with density, but that it is inversely proportional to the elevation of temperature, becomes most evidently corroborated by observations made with water at low temperatures. About 200 experiments, instituted with water at temperatures varying from 0° to 8° centigrade, or 32° to 46·4° Fahr., showed that the well-known anomaly occurring in the density of water, from 32° to 39·2° F., had no influence whatever on its cohesion; and starting from 32° F. cohesion, diminished in a ratio proportional to the increase of temperature.

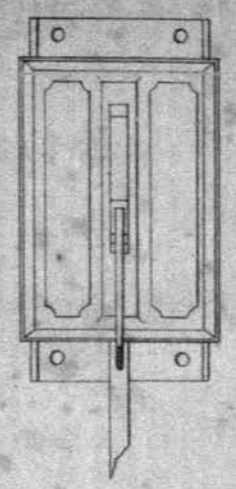
We may, therefore, consider it as established that heat has another influence on cohesion than that caused by mere change of density.

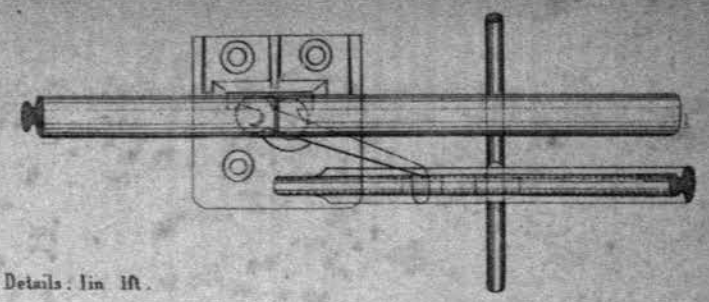
PLATE III.

WILD'S PATENT SWITCH.

SWITCH BOX.

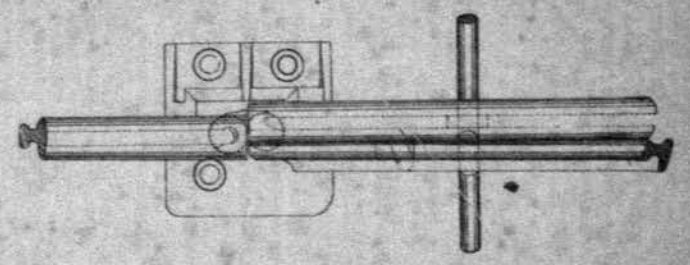


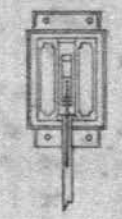


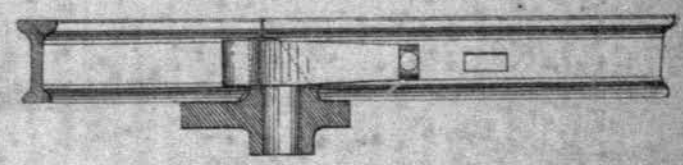


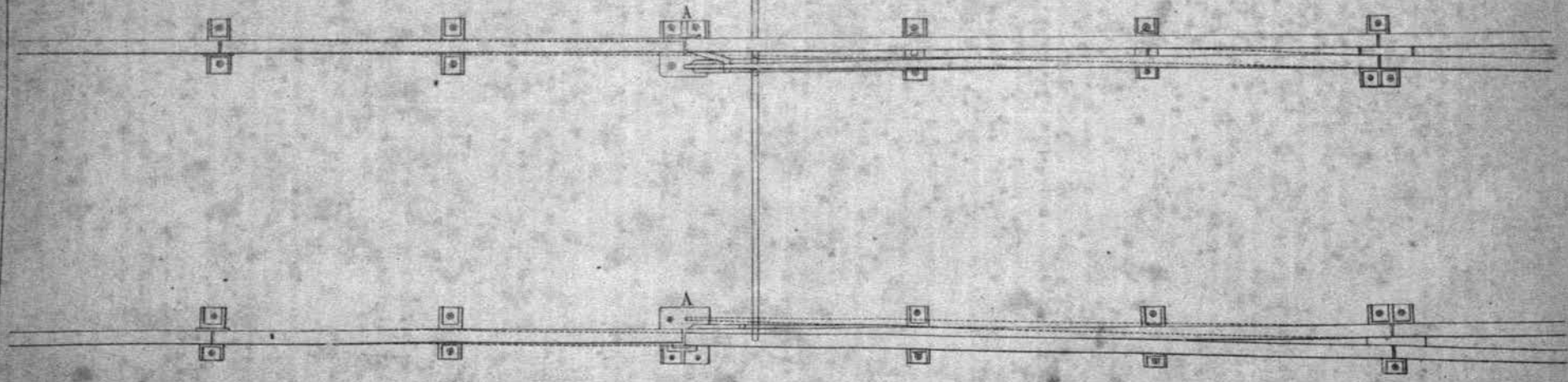
Scale for Details: 1in 1ft.

CHAIRS A A. SHEWING THE TWO POSITIONS OF TONGUE RAILS.









Scale ⅜ in 1ft.

WILD'S RAILWAY SWITCH.

(With an Engraving, Plate III.)

In the present number we give an engraving of a new railway switch. There have been since the first introduction of railways, several arrangements proposed for passing trains from one line of rails to another; the whole of these, however, which have been adopted may be classed under two heads: those in which, in order to effect a change from one line of rails to another, the apparatus had to be moved by hand; and those in which an engine can pass from either of the two diverging lines on to the single line without such aid, clearing the way for itself, should the switch be in the wrong position. These are termed, and are, to a certain extent, self-acting.

The former possessed the advantage of making the guage perfect for either line, but was deficient in the more essential quality of safety; while the latter, to attain this quality, sacrificed the parallelism of guage. In the improved switch the advantages of both are united, the self-acting principle being accompanied with perfect uniformity of guage.

In order to describe the working of the new apparatus, it will be first advisable to refer to the one now mostly employed, in which either tongue rail is embedded in the ordinary rail according to the position of the switch; in this arrangement the guage is always imperfect, as the notch occupied by the end of the tongue rail is, when this is withdrawn, left exposed: this defect is partially provided against by the introduction of a check rail.

In the improved switch, the end of the tongue, when in contact with the rail, is also embedded in a notch, which however ceases to exist when it is no longer required. This motion is effected by causing the rail abutting against the end of the tongue to move in connection with it, but in the opposite direction, so that when the tongue is withdrawn, the protruding rail which formed the notch is withdrawn also.

In all inventions of this class, however ingenious they may appear on paper, practice is the main test of their utility, and we are informed that the invention which we have now noticed, has been for some time in successful operation upon several railways; among which we may mention the Grand Junction, the Manchester and Leeds, the Chester and Birkenhead, and the South Eastern Railways.

THE PLANET BEYOND URANUS.

The memoir of the discovery of the planet beyond Uranus, read by the Astronomer-Royal at the November meeting of the Royal Astronomical Society, has been printed on account of its importance before the remainder of the usual monthly notice was completed. Extracts of Professor Airy's memoir are given below, but for the sake of brevity several parts are omitted, for which we have substituted the paragraphs in brackets.

We wish to direct the reader's attention chiefly to the papers marked 11 and 12, and to the remarks following them. It will be seen from these, that a few days after Mr. Adams had communicated to the Astronomer-Royal *all* the elements of the planet, M. Le Verrier published, in the *Comptes Rendus*, a paper on the perturbations of Uranus, in which he says nothing of their being caused by an exterior planet: we may, therefore, suppose that he had not, at that time, made any discoveries respecting it. Seven months after, M. Le Verrier publishes another paper, in which he, for the first time, speaks of the new planet. The Astronomer-Royal says that he received this paper with "a feeling of delight and satisfaction," because it confirmed the conclusions of Mr. Adams respecting the position of the planet, which he "had perused seven months earlier." It is important to observe that this second paper by M. Le Verrier gave only the position—not the mass and orbit—of the planet, which had been however ascertained by Mr. Adams. The eccentricity of the planet was not discovered by M. Le Verrier till August, 1846—that is, ten months after the Astronomer-Royal received Mr. Adams's determination of it.

It appears that neither the Astronomer-Royal nor Professor Challis thought it worth while to take the trouble of looking for the planet until Le Verrier's paper confirmed that of Mr. Adams. The self-exculpatory tone adopted by the superintendents of the two principal English observatories, does not seem altogether needless. The fact of their both offering apologies, seems to indicate that apologies were necessary. The Astronomer-Royal had "always considered the correctness of a distant mathematical result to be a subject rather of moral than of mathematical evidence." Professor Challis says, in a paper following that by Professor Airy, that his motive for undertaking the search for the predicted planet, was the agreement of M. Le Verrier's "deductions with those of Mr. Adams, together with the recommendation of the Astronomer-Royal." He tells us, also, that he was deterred from commencing the work sooner, because it was "*so novel a thing* to undertake observations in reliance upon merely theoretical deductions."

We have no desire to depreciate M. Le Verrier's labours. On the contrary, they entitle him to high renown. His first paper alone, investigating the perturbations of Uranus without assigning a new cause for them, is a work of the utmost scientific value. But the chief peculiarity of this event in the history of science is the *predictive* evidence and application of the laws of gravitation. Hitherto, the evidence of the truth of those laws, wonderfully minute and varied as it has been, was restricted to the explanation of observed facts; but the most overwhelming evidence of a theory is its capability of anticipating the result of experimental observations before they are actually made. This kind of evidence is furnished in an unexampled degree, by the anticipatory calculation of the mass, &c, of the unseen planet. Regarding, therefore, the prediction of the planet as an event altogether unparalleled, and as the feature of the discovery most important with respect to the evidences of science, we cannot over-estimate the value of the fact established by the Astronomer-Royal, that Mr. Adams was the first *predicter* of the position, mass, and orbit of the new planet.

When the Astronomer-Royal speaks of the discovery as "a consequence of what may properly be called a movement of the age," we must take this as a rhetorical expression, not intended to have any specific meaning. In fact, the utmost that can be made of the sentence is this, that there has for some time existed a general suspicion of the existence of a planet beyond Uranus. The numerical determination of the longitude of the planet (323 34), &c., by an elaborate mathematical investigation, required something a *little* more tangible and definite than a "movement of the age."

It has not been usual to admit into the *Memoirs* of this Society mere historical statements of circumstances which have occurred in our own times. I am not aware that this is a matter of positive regulation: it is, I believe, merely a rule of practice, of which the application in every particular instance has been determined by the discretion of those Officers of the Society with whom the arrangement of our *Memoirs* has principally rested. And there can be no doubt that the ordinary rule must be a rule for the exclusion of papers of this character; and that if a positive regulation is to be made, it must absolutely forbid the presentation of such histories. Yet it is conceivable that events may occur in which this rule ought to be relaxed; and such, I am persuaded, are the circumstances attending the discovery of the planet exterior to *Uranus*. In the whole history of astronomy, I had almost said in the whole history of science, there is nothing comparable to this. The history of the discoveries of new planets in the latter part of the last century, and in the present century, offers nothing analogous to it. *Uranus*, *Ceres*, and *Pallas*, were discovered in the course of researches which did not contemplate the possible discovery of planets. *Juno* and *Vesta* were discovered in following up a series of observations suggested by a theory which, fruitful as it has been, we may almost venture to call fanciful. *Astræa* was found in the course of a well-conducted re-examination of the heavens, apparently contemplating the discovery of a new planet as only one of many possible results. But the motions of *Uranus*, examined by philosophers who were fully impressed with the universality of the law of gravitation, have long exhibited the effects of some disturbing body: mathematicians have at length ventured on the task of ascertaining where such a body could be; they have pointed out that the supposition of a disturbing body moving in a certain orbit, precisely indicated by them, would entirely explain the observed disturbances of *Uranus*: they have expressed their conviction, with a firmness which I must characterise as wonderful, that the disturbing planet would be found exactly in a certain spot, and presenting exactly a certain appearance; and in that spot, and with that appearance, the planet has been found. Nothing in the whole history of astronomy can be compared with this.

The principal steps in the theoretical investigations have been made by one individual, and the published discovery of the planet was necessarily made by one individual. To these persons the public attention has been principally directed; and well do they deserve the honours which they

have received, and which they will continue to receive. Yet we should do wrong if we considered that these two persons alone are to be regarded as the authors of the discovery of this planet. I am confident that it will be found that the discovery is a consequence of what may properly be called a movement of the age; that it has been urged by the feeling of the scientific world in general, and has been nearly perfected by the collateral, but independent labours, of various persons possessing the talents or powers best suited to the different parts of the researches.

With this conviction, it has appeared to me very desirable that the authentic history of this discovery should be published as soon as possible; not only because it will prove a valuable contribution to the history of science, but also because it may tend to do justice to some persons who otherwise would not receive in future times the credit which they deserve. And as a portion of the history, I venture to offer to this Society a statement of the circumstances which have come to my own knowledge. I have thought that I could with propriety do this: not because I can pretend to know all the history of the discovery, but because I know a considerable part of it; and because I can lay claim to the character of impartiality to this extent, that, though partaking of the general movement of the age, I have not directly contributed either to the theoretical or to the observing parts of the discovery. In a matter of this delicacy I have thought it best to act on my own judgment, without consulting any other person; I have, however, solicited the permission of my English correspondents for the publication of letters.

Without pretending to fix upon a time when the conviction of the irreconcilability of the motions of *Uranus* with the law of gravitation first fixed itself in the minds of some individuals, we may without hesitation date the general belief in this irreconcilability from the publication of M. Alexis Bouvard's *Tables of Uranus* in 1821. It was fully shown in the introduction to the tables, that, when every correction for perturbation indicated by the best existing theories was applied, it was still impossible to reconcile the observations of Flamsteed, Lemonnier, Bradley, and Mayer, with the orbit required by the observations made after 1781: and the elements of the orbit were adopted from the latter observations, leaving the discordances with the former (amounting sometimes to three minutes of arc) for future explanation.

The orbit thus adopted represented pretty well the observations made in the years immediately following the publication of the tables. But in five or six years the discordance again growing up became so great, that it could not escape notice. A small error was shown by the Kremsmünster Observations of 1825 and 1826: but, perhaps, I am not in error in stating that the discordance was first prominently exhibited in the Cambrige Observations, the publication of which from 1828 was conducted under my superintendence.

[Here intervene letters from Mr. Hussey (1834) and M. Bouvard (1837), surmising that the perturbations might be produced by an unseen body.]

I have departed from a strictly chronological order for the sake of keeping in connexion the papers which relate to the same trains of investigation. Several months before the date of the last letter quoted, I had received the first intimation of those calculations which have led to a distinct indication of the place where the disturbing planet ought to be sought. The date of the following letter is Feb. 13, 1844:—

No. 6.—Professor CHALLIS to G. B. AIRY.

[EXTRACT.]

"*Cambridge Observatory, Feb.* 13, 1844.

"A young friend of mine, Mr. Adams, of St. John's College, is working at the theory of *Uranus*, and is desirous of obtaining errors of the tabular geocentric longitudes of this planet, when near opposition, in the years 1818-1826, with the factors for reducing them to errors of heliocentric longitude. Are your reductions of the planetary observations so far advanced that you could furnish these data? and is the request one which you have any objection to comply with? If Mr. Adams may be favoured in this respect, he is further desirous of knowing, whether in the calculation of the tabular errors any alterations have been made in Bouvard's *Tables of Uranus* besides that of *Jupiter's* mass."

No. 7.—G. B. AIRY to Professor CHALLIS.

[EXTRACT.]

"*Royal Observatory, Greenwich*, 1844, *Feb.* 15.

"I send all the results of the observations of *Uranus* made with both instruments [that is, the heliocentric errors of *Uranus* in longitude and latitude from 1754 to 1830, for all those days on which there were observations, both of right ascension and of polar distance]. No alteration is made in Bouvard's *Tables of Uranus*, except increasing the two equations which depend on *Jupiter* by $\frac{1}{100}$ part. As constants have been added (in the printed tables) to make the equations positive, and as $\frac{1}{100}$ part of the numbers in the tables has been added, $\frac{1}{100}$ part of the constants has been subtracted from the final results."

No. 8.—Professor CHALLIS to G. B. AIRY.

[EXTRACT.]

"*Cambridge Observatory, Feb.* 16, 1844.

"I am exceedingly obliged by your sending so complete a series of tabular errors of *Uranus*. * * * The list you have sent will give Mr. Adams the means of carrying on in the most effective manner the inquiry in which he is engaged.

No. 9.—Professor CHALLIS to G. B. AIRY.

"*Cambridge Observatory Sept.* 22, 1845

"My friend Mr. Adams (who will probably deliver this note to you) has completed his calculations respecting the perturbation of the orbit of *Uranus* by a supposed ulterior planet, and has arrived at results which he would be glad to communicate to you personally, if you could spare him a few moments of your valuable time. His calculations are founded on the observations you were so good as to furnish him with some time ago; and from his character as a mathematician, and his practice in calculation, I should consider the deductions from his premises to be made in a trustworthy manner. If he should not have the good fortune to see you at Greenwich, he hopes to be allowed to write to you on this subject."

No. 10.—G. B. AIRY to Professor CHALLIS.

"*Royal Observatory, Greenwich*, 1845, *Sept.* 29.

"I was, I suppose, on my way from France, when Mr. Adams called here: at all events, I had not reached home, and therefore, to my regret, I have not seen him. Would you mention to Mr. Adams that I am very much interested with the subject of his investigations, and that I should be delighted to hear of them by letter from him?"

On one of the last days of October, 1845, Mr. Adams called at the Royal Observatory, Greenwich, in my absence, and left the following important paper:—

No. 11.—J. C. ADAMS, Esq. to G. B. AIRY.

"According to my calculations, the observed irregularities in the motion of *Uranus* may be accounted for by supposing the existence of an exterior planet, the mass and orbit of which are as follows:—

Mean Distance (assumed nearly in accordance with Bode's law)	38·4
Mean Sidereal Motion in 365·25 days	1°30′·9
Mean Longitude, 1st October, 1845	323 34
Longitude of Perihelion	315 55
Eccentricity	0·1610.
Mass (that of the Sun being unity)	0·0001656.

For the modern observations I have used the method of normal places, taking the mean of the tabular errors, as given by observations near three consecutive oppositions, to correspond with the mean of the times; and the Greenwich observations have been used down to 1830: since which, the Cambridge and Greenwich observations, and those given in the *Astronomische Nachrichten*, have been made use of. The following are the remaining errors of mean longitude:—

Observation—Theory.

1780	+0″·27	1801	−0″·04	1822	+0″·30
1783	−0 ·23	1804	+1 ·76	1825	+1 ·92
1786	−0 ·96	1807	−0 ·21	1828	+2 ·25
1789	+1 ·82	1810	+0 ·56	1831	−1 ·06
1792	−0 ·91	1813	−0 ·94	1834	−1 ·44
1795	+0 ·99	1816	−0 ·31	1837	−1 ·62
1798	−0 ·99	1819	−2 ·00	1840	+1 ·73

The error for 1780 is concluded from that for 1781 given by observation, compared with those of four or five following years, and also with Lemonnier's observations in 1769 and 1771.

"For the ancient observations, the following are the remaining errors:—

Observation—Theory.

1690	+44′·4	1750	−1″·6	1763	−5″·1
1712	+6 ·7	1753	+5 ·7	1769	+0 ·6
1715	−6 ·8	1756	−4 ·0	1771	+11 ·8

The errors are small, except for Flamsteed's observation of 1690. This being an isolated observation, very distant from the rest, I thought it best not to use it in forming the equations of condition. It is not improbable, however, that this error might be destroyed by a small change in the assumed mean motion of the planet."

I acknowledged the receipt of this paper in the following terms:—

No. 12.—G. B. AIRY to J. C. ADAMS, Esq.

"*Royal Observatory, Greenwich*, 1845, *Nov.* 5.

"I am very much obliged by the paper of results which you left here a few days since, showing the perturbations on the place of *Uranus* produced by a planet with certain assumed elements. The latter numbers are all extremely satisfactory: I am not enough acquainted with Flamsteed's observations about 1690 to say whether they bear such an error, but I think it extremely probable.

"But I should be very glad to know whether this assumed perturbation will explain the error of the radius vector of *Uranus*. This error is now very considerable, as you will be able to ascertain by comparing the normal equations, given in the Greenwich observations for each year, for the times *before* opposition with the times *after* opposition."

I have before stated, that I consider the establishment of this error of the radius vector of *Uranus* to be a very important determination. I therefore considered that the trial, whether the error of the radius vector would be explained by the same theory which explained the error of longitude would be truly an *experimentum crucis*. And I waited with much anxiety for Mr. Adams's answer to my query. Had it been in the affirmative, I

should at once have exerted all the influence which I might possess, either directly, or indirectly through my friend Professor Challis, to procure the publication of Mr. Adams's theory.*

From some cause with which I am unacquainted, probably an accidental one, I received no immediate answer to this inquiry. I regret this deeply, for many reasons.

While I was expecting more complete information on Mr. Adams's theory, the results of a new and most important investigation reached me from another quarter. In the *Compte Rendu* of the French Academy for the 10th Nov., 1845, which arrived in this country in December, there is a paper by M. Le Verrier on the perturbations of *Uranus* produced by *Jupiter* and *Saturn*, and on the errors in the elliptic elements of *Uranus*, consequent on the use of erroneous perturbations in the treatment of the observations. It is impossible for me here to enter into details as to the conclusions of this valuable memoir; I shall only say that, while the correctness of the former theories, as far as they went, was generally established, many small terms were added; that the accuracy of the calculations was established by duplicate investigations, following different courses, and executed with extraordinary labour; that the corrections to the elements, produced by treating the former observations with these corrected perturbations, were obtained; and that the correction to the ephemeris for the present time, produced by the introduction of the new perturbations and the new elements, was investigated and found to be incapable of explaining the observed irregularity of *Uranus*. Perhaps it may be truly said that the theory of *Uranus* was now, for the first time, placed on a satisfactory foundation. This important labour, as M. Le Verrier states, was undertaken at the urgent request of M. Arago.

In the *Compte Rendu* for June 1, 1846, M. Le Verrier gave his second memoir on the theory of *Uranus*. The first part contains the results of a new reduction of nearly all the existing observations of *Uranus*, and their treatment with reference to the theory of perturbations, as amended in the former memoir. After concluding from this reduction that the observations are absolutely irreconcilable with the theory, M. Le Verrier considers in the second part all the possible explanations of the discordance, and concludes that none is admissible, except that of a disturbing planet exterior to *Uranus*. He then proceeds to investigate the elements of the orbit of such a planet, assuming that its mean distance is double that of *Uranus*, and that its orbit is in the plane of the ecliptic. The value of the mean distance, it is to be remarked, is not fixed entirely by Bode's law, although suggested by it; several considerations are stated which compel us to take a mean distance, not very greatly differing from that suggested by the law, but which nevertheless, without the suggestion of that law, would leave the mean distance in a most troublesome uncertainty. The peculiarity of the form which the investigation takes is then explained. Finally, M. Le Verrier gives as the most probable result of his investigations, that the true longitude of the disturbing planet for the beginning of 1847 must be about 325°, and that an error of 10° in this place is not probable. No elements of the orbit or mass of the planet are given.

This memoir reached me about the 23rd or 24th of June. I cannot sufficiently express the feeling of delight and satisfaction which I received from it. The place which it assigned to the disturbing planet was the same, to one degree, as that given by Mr. Adams's calculations, which I had perused seven months earlier. To this time I had considered that there was still room for doubt of the accuracy of Mr. Adams's investigations; for I think that the results of algebraic and numerical computations, so long and so complicated as those of an inverse problem of perturbations, are liable to many risks of error in the details of the process: I know that there are important numerical errors in the *Mécanique Céleste* of Laplace; in the *Théorie de la Lune* of Plana; above all, in Bouvard's first tables of *Jupiter* and *Saturn*; and to express it in a word, I have always considered the correctness of a distant mathematical result to be a subject rather of moral than of mathematical evidence. But now I felt no doubt of the accuracy of both calculations, as applied to the perturbation in longitude. I was, however, still desirous, as before, of learning whether the perturbation in radius vector was fully explained. I therefore addressed to M. Le Verrier the following letter:—

No. 13.—G. B. Airy to M. Le Verrier.

"*Royal Observatory, Greenwich*, 1846, *June* 26.

"I have read, with very great interest, the account of your investigations on the probable place of a planet disturbing the motions of *Uranus*, which is contained in the *Compte Rendu de l' Académie* of June 1; and I now beg leave to trouble you with the following question. It appears, from all the later observations of *Uranus* made at Greenwich (which are most completely reduced in the *Greenwich Observations* of each year, so as to exhibit the effect of an error either in the tabular heliocentric longitude, or the tabular radius vector), that the tabular radius vector is considerably too small. And I wish to inquire of you whether this would be a consequence of the disturbance produced by an exterior planet, now in the position which you have indicated?

"I imagine that it would not be so, because the principal term of the inequality would probably be analogous to the moon's variation, or would depend on sin $2(v-v')$; and in that case the perturbation in radius vector would have the sign—for the present relative position of the planet and *Uranus*. But this analogy is worth little, until it is supported by proper symbolical computations.

"By the earliest opportunity I shall have the honour of transmitting to you a copy of the *Planetary Reductions*, in which you will find all the observations made at Greenwich to 1830 carefully reduced and compared with the tables."

Before I could receive M. Le Verrier's answer, a transaction occurred which had some influence on the conduct of English astronomers.

On the 29th of June, a meeting of the Board of Visitors of the Royal Observatory of Greenwich was held, for the consideration of special business. At this meeting, Sir J. Herschel and Professor Challis (among other members of the Board) were present; I was also present, by invitation of the Board. The discussion led, incidentally, to the general question of the advantage of distributing subjects of observation among different observatories. I spoke strongly in favour of such distribution; and I produced, as an instance, the extreme probability of now discovering a new planet in a very short time, provided the powers of one observatory could be directed to the search for it. I gave, as the reason upon which this probability was based, the very close coincidence between the results of Mr. Adams's and M. Le Verrier's investigations of the place of the supposed planet disturbing *Uranus*. I am authorised by Sir J. Herschel's printed statement in the *Athenæum* of October 3, to ascribe to the strong expressions which I then used the remarkable sentence in Sir J. Herschel's address, on September 10, to the British Association assembled at Southampton. "We see it [the probable new planet] as Columbus saw America from the shores of Spain. Its movements have been felt, trembling along the far-reaching line of our analysis, with a certainty hardly inferior to that of ocular demonstration."* And I am authorised by Professor Challis, in oral conversation, to state that the same expressions of mine induced him to contemplate the search for the suspected planet.

[M. Le Verrier's reply follows, in which he says that M. Bouvard calculated incorrectly the orbit of Uranus, in ignorance of the exterior planet, and that the error of the radius vector of Uranus arises from errors of its eccentricity and longitude of perihelion.

The following letter is from Professor Airy to Professor Challis, requesting the latter to undertake the search at Cambridge, with the Northumberland equatorial telescope, as the only instrument in England large enough for the purpose.]

In explanation of this letter, it may be necessary to state that, in common I believe with other astronomers at that time, I thought it likely that the planet would be visible only in large telescopes. I knew that the Observatory of Cambridge was at this time oppressed with work, and I thought that the undertaking—a survey of such an extent as this seemed likely to prove—would be entirely beyond the powers of its personal establishment. Had Professor Challis assented to my proposal of assistance, I was prepared immediately to place at his disposal the services of an efficient assistant; and for approval of such a step, and for liquidation of the expense which must thus be thrown on the Royal Observatory, I should have referred to a Government which I have never known to be illiberal when demands for the benefit of science were made by persons whose character and position offered a guarantee, that the assistance was fairly asked for science, and that the money would be managed with fair frugality. In the very improbable event of the Government refusing such indemnity, I was prepared to take all consequences on myself.

On the 13th of July, I transmitted to Professor Challis "Suggestions for the Examination of a Portion of the Heavens in search of the external Planet which is presumed to exist and to produce disturbance in the motion of *Uranus*," and I accompanied them with the following letter:—

No. 16.—G. B. Airy to Professor Challis.

"*Royal Observatory, Greenwich*, 1846, *July* 13.

"I have drawn up the enclosed paper, in order to give you a notion of the extent of work incidental to a sweep for the possible planet.

"I only add at present that, in my opinion, the importance of this inquiry exceeds that of any current work, which is of such a nature as not to be totally lost by delay."

My "Suggestions" contemplated the examination of a part of the heavens 30° long, in the direction of the ecliptic, and 10° broad. They entered into considerable details as to the method which I proposed; details which were necessary, in order to form an estimate of the number of hours' work likely to be employed in the sweep.

I received, in a few days, the following answer:—

No. 17.—Professor Challis to G. B. Airy.

[EXTRACTS.]

"*Cambridge Observatory, July* 18, 1846.

"I have only just returned from my excursion. * * * I have determined on sweeping for this hypothetical planet. * * * With respect to your proposal of supplying an assistant I need not say anything, as I understand it to be made on the supposition that I decline undertaking the search myself. * * * I purpose to carry the sweep to the extent you recommend."

* Here the Astronomer Royal explained to the meeting, by means of a diagram, the nature of the errors of the tabular radius vector.

* This sentence is copied from the written draft of the speech. Sir J. Herschel appeared to suppose that the sentence had not been reported in the public journals as spoken. I did, however, see it so reported in an English newspaper, to which I had access on the Continent.

The remainder of the letter was principally occupied with the details of a plan of observing different from mine, and of which the advantage was fully proved in the practical observation.

On August 7, Professor Challis, writing to my confidential assistant (Mr. Main) in my supposed absence, said,—

No. 18.—Professor CHALLIS to the Rev. R. MAIN.

[EXTRACT.]

"*Cambridge Observatory, August* 7, 1846.

"I have undertaken to search for the supposed new planet more distant than *Uranus*. Already I have made trial of two different methods of observing. In one method, recommended by Mr. Airy * * * I met with a difficulty which I had anticipated. * * * I adopted a second method."

From a subsequent letter (to be cited hereafter), it appears that Professor Challis had commenced the search on July 29, and had actually observed the planet on August 4, 1846.

Mr. Main's answer to the other parts of this letter, written by my direction, is dated August 8.

At Wiesbaden (which place I left on September 7), I received the following letter from Professor Challis :—

No. 19.—Professor CHALLIS to G. B. AIRY.

[EXTRACT.]

"*Cambridge Observatory, Sept.* 2, 1846.

"I have lost no opportunity of searching for the planet; and the nights having been generally pretty good, I have taken a considerable number of observations: but I get over the ground very slowly, thinking it right to include all stars to 10-11 magnitude; and I find, that to scrutinise, thoroughly, in this way the proposed portion of the heavens, will require many more observations than I can take this year."

On the same day on which Professor Challis wrote this letter, Mr. Adams, who was not aware of my absence from England, addressed the following very important letter to Greenwich :—

No. 20.—J. C. ADAMS, Esq., to G. B. AIRY.

"*St. John's College, Cambridge, Sept.* 2, 1846.

"In the investigation, the results of which I communicated to you last October, the mean distance of the supposed disturbing planet is assumed to be twice that of *Uranus*. Some assumption is necessary in the first instance, and Bode's law renders it probable that the above distance is not very remote from the truth: but the investigation could scarcely be considered satisfactory while based on any thing arbitrary; and I therefore determined to repeat the calculation, making a different hypothesis as to the mean distance. The eccentricity also resulting from my former calculations was far too large to be probable; and I found that, although the agreement between theory and observation continued very satisfactory down to 1840, the difference in subsequent years was becoming very sensible, and I hoped that these errors, as well as the eccentricity, might be diminished by taking a different mean distance. Not to make too violent a change, I assumed this distance to be less than the former value by about $\frac{1}{30}$th part of the whole. The result is very satisfactory, and appears to show that, by still further diminishing the distance, the agreement between the theory and the later observations may be rendered complete, and the eccentricity reduced at the same time to a very small quantity. The mass and the elements of the orbit of the supposed planet, which result from the two hypotheses, are as follows :—

	Hypothesis I. $\left(\frac{a}{a'}=0{\cdot}5\right)$	Hypothesis II. $\left(\frac{a}{a'}=0.515\right)$
Mean Longitude of Planet, 1st Oct. 1846	325° 8′	323° 2′
Longitude of Perihelion ..	315 57	299 11
Eccentricity	0·16103	0·12062
Mass (that of Sun being 1) ..	0·00016563	0·00015003

"This investigation has been conducted in the same manner in both cases, so that the differences between the two sets of elements may be considered as wholly due to the variation of the fundamental hypothesis. The following table exhibits the differences between the theory and the observations which were used as the basis of calculation. The quantities given are the errors of *mean* longitude, which I found it more convenient to employ in my investigations than those of the true longitude.

Ancient Observations.

Date.	(Obs. — Theory.) Hypoth. I.	Hypoth. II.	Date.	(Obs. — Theory.) Hypoth. I.	Hypoth. II.
1712	+6″·7	+6″·3	1756	— 4″·0	— 4″·0
1715	—6 ·8	—6 ·6	1764	— 5 ·1	— 4 ·1
1750	—1 ·6	—2 ·6	1769	+ 0 ·6	+ 1 ·8
1753	+5 ·7	+5 ·2	1771	+11 ·8	+12 ·8

Modern Observations.

1780	+0″·27	+0″·54	1810	+0″·56	+0″·61
1783	—0 ·23	—0 ·21	1813	—0 ·94	—1 ·00
1786	—0 ·36	—1 ·00	1816	—0 ·31	—0 ·46
1789	+1 ·82	+1 ·63	1819	—2 ·00	—2 ·19
1792	—0 ·91	—1 ·06	1822	+0 ·30	+0 ·14
1795	+0 ·09	+0 ·04	1825	+1 ·92	+1 ·87
1798	—0 ·99	—0 ·93	1828	+2 ·25	+2 ·35
1801	—0 ·04	+0 ·11	1831	—1 ·06	—0 ·82
1804	+1 ·76	+1 ·94	1834	—1 ·44	—1 ·17
1807	—0 ·21	—0 ·08	1837	—1 ·62	—1 ·53
1810	+0 ·56	+0 ·61	1840	+1 ·73	+1 ·31

"The greatest difference in the above table, viz. that for 1771, is deduced from a single observation, whereas the difference immediately preceding, which is deduced from the mean of several observations, is much smaller. The error of the tables for 1780 is found by interpolating between the errors given by the observations of 1781, 1782, and 1783, and those of 1769 and 1771. The differences between the results of the two hypotheses are exceedingly small till we come to the last years of the series, and become sensible precisely at the point where both sets of results begin to diverge from the observations; the errors corresponding to the second hypothesis being, however, uniformly smaller. The errors given by the *Greenwich Observations* of 1843 are very sensible, being for the first hypothesis + 6″·84, and for the second + 5″·50. By comparing these errors, it may be inferred that the agreement of theory and observation would be rendered very close by assuming $\frac{a}{a'} = 0{\cdot}57$, and the corresponding mean longitude on the 1st October, 1846, would be about 315° 20′, which I am inclined to think is not far from the truth. It is plain also that the eccentricity corresponding to this value $\frac{a}{a'}$, would be very small. In consequence of the divergence of the results of the two hypotheses, still later observations would be most valuable for correcting the distances, and I should feel exceedingly obliged if you would kindly communicate to me two normal places near the oppositions of 1844 and 1845.

"As Flamsteed's first observation of *Uranus* (in 1690) is a single one, and the interval between it and the rest is so large, I thought it unsafe to employ this observation in forming the equations of condition. On comparing it with the theory, I find the difference to be rather large, and greater for the second hypothesis than for the first, the errors being + 44″·5 and + 50″·0 respectively. If the error be supposed to change in proportion to the change of mean distance, its value corresponding to $\frac{a}{a'}=0{\cdot}57$, will be about + 70″, and the error in the time of transit will be between 4′ and 5′. It would be desirable to ascertain whether Flamsteed's manuscripts throw any light on this point.

"The corrections of the tabular radius vector of *Uranus*, given by the theory for some late years, are as follows :—

Date.	Hypoth. I.	Hypoth II.
1834	+0·005051	+0·004923
1840	+0·007219	+0·006962
1846	+0·008676	+0·008250

"The correction for 1834 is very nearly the same as that which you have deduced from observation, in the *Astronomische Nachrichten*; but the increase in later years is more rapid than the observations appear to give it: the second hypothesis, however, still having the advantage.

"I am at present employed in discussing the errors in latitude, with the view of obtaining an approximate value of the inclination and position of the node of the new planet's orbit; but the perturbations in latitude are so very small that I am afraid the result will not have great weight. According to a rough calculation made some time since, the inclination appeared to be rather large, and the longitude of the ascending node to be about 300°; but I am now treating the subject much more completely, and hope to obtain the result in a few days.

"I have been thinking of drawing up a brief account of my investigation to present to the British Association."

Mr. Main, acting for the Astronomer Royal in his absence, answered this letter as follows :—

No. 21.—The Rev. R. MAIN to J. C. ADAMS, Esq.

"*Royal Observatory, Greenwich*, 1846, *Sept.* 5.

"The Astronomer Royal is not at home, and he will be absent for some time; but it appears to me of so much importance that you should have immediately the normal errors of *Uranus* for 1844 and 1845, that I herewith send you the former (the volume for 1844 has been published for some time), and I shall probably be able to send you those for 1845 on Tuesday next, as I have given directions to have the computations finished immediately. If a place (geocentric) for the present year should be of value to you, I could probably send one in a few days."

In acknowledging this letter, Mr. Adams used the following expression:

No. 22.—J. C. ADAMS, Esq. to the Rev. R. MAIN.

[EXTRACT.]

"*St. John's College, Cambridge, 7th Sept.* 1846.

"I hope by to-morrow to have obtained approximate values of the inclination and longitude of the node."

On the same day, Sept. 7, Mr. Main transmitted to Mr. Adams the normal places for 1845, to which allusion was made in the letter of September 5.

On the 31st of August, M. Le Verrier's second paper on the place of the

disturbing planet (the third paper on the motion of *Uranus*) was communicated to the French Academy. I place the notice of this paper after those of September 2, &c. because, in the usual course of transmission to this country, the number of the *Comptes Rendus* containing this paper would not arrive here, at the earliest, before the third or fourth week in September; and it does not appear that any earlier notice of its contents was received in England.

It is not my design here to give a complete analysis of this remarkable paper; but I may advert to some of its principal points. M. Le Verrier states that, considering the extreme difficulty of attempting to solve the problem in all its generality, and considering that the mean distance and the epoch of the disturbing planet were determined approximately by his former investigations, he adopted the corrections to these elements as two of the unknown quantities to be investigated. Besides these, there are the planet's mass, and two quantities from which the eccentricity and the longitude of perihelion may be inferred; making, in all, five unknown quantities depending solely on the orbit and mass of the disturbing planet. Then there are the possible corrections to the mean distance of *Uranus*, to its epoch of longitude, to its longitude of perihelion, and to its eccentricity; making, in all, nine unknown quantities. To obtain these, M. Le Verrier groups all the observations into thirty-three equations. He then explains the peculiar method by which he derives the values of the unknown quantities from these equations. The elements obtained are,—

Semi-axis Major	.	36·154 $\left(\text{or } \frac{a}{a'} = 0{\cdot}531\right)$
Periodic Time	.	217y·387
Eccentricity	.	0·10761
Longitude of Perihelion		284° 45′
Mean Longitude, 1 Jan. 1847		318 47
Mass $\frac{1}{9600} = 0{\cdot}0001075$		
True Heliocentric Longitude, 1 Jan. 1847		326° 32′
Distance from the Sun	. .	33·06

It is interesting to compare these elements with those obtained by Mr. Adams. The difference between each of these and the corresponding element obtained by Mr. Adams in his second hypothesis is, in every instance, of that kind which corresponds to the further change in the assumed mean distance recommended by Mr. Adams. The agreement with observations does not appear to be better than that obtained from Mr. Adams's elements, with the exception of Flamsteed's first observation of 1690, for which (contrary to Mr. Adams's expectation) the discordance is considerably diminished.

M. Le Verrier then enters into a most ingenious computation of the limits between which the planet must be sought. The principle is this: assuming a time of revolution, all the other unknown quantities may be varied in such a manner, that though the observations will not be so well represented as before, yet the errors of observation will be tolerable. At last, on continuing the variation of elements, one error of observation will be intolerably great. Then, by varying the elements in another way, we may at length make another error of observation intolerably great; and so on. If we compute, for all these different varieties of elements, the place of the planet for 1847, its *locus* will evidently be a discontinuous curve or curvilinear polygon. If we do the same thing with different periodic times, we shall get different polygons; and the extreme periodic times that can be allowed will be indicated by the polygons becoming points. These extreme periodic times are 207 and 233 years. If now we draw one grand curve, circumscribing all the polygons, it is certain that the planet must be within that curve. In one direction, M. Le Verrier found no difficulty in assigning a limit; in the other he was obliged to restrict it, by assuming a limit to the eccentricity. Thus he found that the longitude of the planet was certainly not less than 321°, and not greater than 335° or 345°, according as we limit the eccentricity to 0·125 or 0·2. And if we adopt 0·125 as the limit, then the mass will be included between the limits 0·00007 and 0·00021; either of which exceeds that of *Uranus*. From this circumstance, combined with a probable hypothesis as to the density, M. Le Verrier concluded that the planet would have a visible disk, and sufficient light to make it conspicuous in ordinary telescopes.

M. Le Verrier then remarks, as one of the strong proofs of the correctness of the general theory, that the error of radius vector is explained as accurately as the error of longitude. And finally, he gives his opinion that the latitude of the disturbing planet must be small.

My analysis of this paper has necessarily been exceedingly imperfect, as regards the astronomical and mathematical parts of it; but I am sensible that, in regard to another part, it fails totally. I cannot attempt to convey to you the impression which was made on me by the author's undoubting confidence in the general truth of his theory, by the calmness and clearness with which he limited the field of observation, and by the firmness with which he proclaimed to observing astronomers, "Look in the place which I have indicated, and you will see the planet well." Since Copernicus* declared that, when means should be discovered for improving the vision, it would be found that *Venus* had phases like the moon, nothing (in my opinion) so bold, and so justifiably bold, has been uttered in astronomical prediction. It is here, if I mistake not, that we see a character far superior to that of the able, or enterprising, or industrious mathematician; it is here that we see the philosopher. The mathematical investigations will doubtless be published in detail; and they will, as mathematical studies, be highly instructive: but no details published after the planet's discovery can ever have for me the charm which I have found in this abstract which preceded the discovery.

I understand that M. Le Verrier communicated his principal conclusions to the astronomers of the Berlin Observatory on September 23, and that, guided by them, and comparing their observations with a star-map, they found the planet on the same evening. And I am warranted by the verbal assurances of Professor Challis in stating that, having received the paper on September 29, he was so much impressed with the sagacity and clearness of M. Le Verrier's limitations of the field of observation, that he instantly changed his plan of observing, and noted the planet, as an object having a visible disk, on the evening of the same day.

My account, as a documentary history, supported by letters written during the events, is properly terminated; but I think it advisable, for the sake of clearness, to annex extracts from a letter which I have received from Professor Challis since the beginning of October, when I returned to England.

[In this letter Professor Challis details his labours in search for the planet, and states that on September 29, he singled out one star of 300 observed that evening, for which he noted, "seems to have a disk." This turned out to be the planet.]

Before terminating this account, I beg leave to present the following remarks:—

First. It would not be just to institute a comparison between papers which at this time exist only in manuscript, and papers which have been printed by their authors; the latter being in all cases more complete and more elaborately worked out than the former.

Second. I trust that I am amply supported, by the documentary history which I have produced, in the view which I first took, namely, that the discovery of this new planet is the effect of a movement of the age. It is shown, not merely by the circumstance that different mathematicians have simultaneously but independently been carrying on the same investigations, and that different astronomers, acting without concert, have at the same time been looking for the planet in the same part of the heavens; but also by the circumstance that the minds of these philosophers, and of the persons about them, had long been influenced by the knowledge of what had been done by others, and of what had yet been left untried; and that in all parts of the work the mathematician and the astronomer were supported by the exhortations and the sympathy of those whose opinions they valued most. I do not consider this as detracting in the smallest degree from the merits of the persons who have been actually engaged in these investigations.

Third. This history presents a remarkable instance of the importance, in doubtful cases, of using any received theory as far as it will go, even if that theory can claim no higher merit than that of being plausible. If the mathematicians whose labours I have described had not adopted Bode's law of distances (a law for which no physical theory of the rudest kind has ever been suggested), they would never have arrived at the elements of the orbit. At the same time, this assumption of the law is only an aid to calculation, and does not at all compel the computer to confine himself perpetually to the condition assigned by this law, as will have been remarked in the ultimate change of mean distance made by both the mathematicians, who have used Bode's law to give the first approximation to mean distance.

Fourth. The history of this discovery shows that, in certain cases, it is advantageous for the progress of science that the publication of theories, when so far matured as to leave no doubt of their general accuracy, should not be delayed till they are worked to the highest imaginable perfection. It appears to be quite within probability, that a publication of the elements obtained in October 1845 might have led to the discovery of the planet in November 1845.

I have now only to request the indulgence of my hearers for the apparently egotistical character of the account which I have here given; a character which it is extremely difficult to remove from a history that is almost strictly confined to transactions with which I have myself been concerned.

* I borrow this history from Smith's Optics, sect. 1050. Since reading this Memoir, I have, however, been informed by Professor De Morgan, that the printed works of Copernicus do not at all support this history, and that Copernicus appears to have believed that the planets are self-luminous.—G. B. A

THE GOVERNMENT SCHOOL OF DESIGN.

Though a considerable time has elapsed since the following report on the French Schools was presented by Mr. Poynter to the Council of this Institution, it has remained unpublished. The Council have since sanctioned its publication, and as the subject of the document is not of temporary interest, it is well worthy of perusal.

"My Lords and Gentlemen,—Previously to entering upon the exercise of the office to which the Council have done me the honour to appoint me, I considered that a more intimate knowledge of the system of instruction adopted in the French Schools, and its results, would enable me to judge more advantageously of the condition and prospects of our own. I have, therefore, visited Paris with a special view to this subject; and would willingly have extended my journey to Lyons, had time permitted. But

although it was out of my power actually to inspect any other School than that of Paris, I have had the advantage of obtaining an intimate acquaintance with the Schools of Lyons and Toulouse, through the Reports lately made by M. Charles Texier, commissioned by the Government to inspect the Schools of Art, which were very obligingly placed in my hands for perusal.

"The Report laid last year before the Council by Mr. Townsend, will render superfluous any detailed account of the views entertained with regard to industrial art, and the system upon which they are carried out, in the School of Paris; I shall therefore notice merely such points as it occurred to me might be of importance with reference to our own Schools, and which may be mentioned without needless repetition.

"The course of instruction at Paris is divided into three main branches: 1. The Figure; 2. Ornament; 3. Architecture and Geometry. These three courses of study (subdivided and classified) are taught on alternate days, in the order named, a day being devoted to each; but the limited space to which the School premises are confined has caused a most inconvenient system of taking the classes in relays, greatly to their disadvantage. The students are admitted free of charge, and no pledge is required from them of their exclusive devotion to any branch of industrial art; many, it is well known, pass from the elementary classes of the *Ecole de Dessin* to the *Ecole des Beaux Arts*, in order to follow the higher branches of painting and sculpture; but this is not considered to militate in any way against the usefulness of the School, as a nursery of art applied to manufactures. To extend a sound knowledge of art in general is held to be the best mode of securing a supply of artists for industrial purposes. The only condition to which the pupils are bound is, that if they remain in the School they must follow up the whole course of study prescribed by the regulations. Exceptions are made in favour of artisans who wish to take advantage of the means afforded by the School to increase their knowledge and improve their taste. This class of students, however, have recourse more generally to the *Ecole Communale*,—for an account of which I must refer to Mr. Townsend's Report.

"There is one branch of instruction in the Paris School which I beg leave to offer to the special notice of the Council—a course of lectures on the History of Ornament, illustrated by examples drawn by the Professor in the absence of the pupils. These examples he sketches to a working scale, on large canvas covered with paper. They consist of a chronological series of every class of ornament, beginning with the Greek, and followed throughout all styles and all ages, explaining their origin, their connexion with each other, and the peculiar characteristics by which they are to be discriminated. Each lecture is a continuation of the subject from that which precedes it; and the Professor is bound by his engagement to vary the examples during the period of three years. This professorship is held by a pupil of M. Constant Dufeux, the Architect to the School; and the first requisite toward the establishment of a similar class elsewhere would be, to find an artist with the knowledge of ornament possessed by this gentleman united to the handicraft skill with which he expresses its forms, and brings them out in the truest effects of chiar'-oscuro by the most simple manipulation in black and white. It would be very desirable to possess some of this gentleman's sketches in our School, as examples of masterly execution in this branch of art. I mentioned this to the Director, M. Belloc, and have no doubt they might be obtained if the Council thought proper.

"An excellent plan is adopted in the Mathematical Class to secure to all the pupils the full benefit of the instructions given by the Professor. It is not to be expected that mathematical demonstrations will be comprehended by a whole class the first time of explanation; those pupils, therefore, who have understood the lesson, are charged with repeating it to those of slower apprehension, until it is made clear to every individual.

"I beg leave to enter somewhat more particularly upon a subject which has ever been regarded with great interest in our own establishment, namely, the Female School. This branch is placed, at Paris, under the superintendence of two *Dames Directrices*, who divide the labour of teaching. There are two classes in the day, each of about fifty pupils, a division rendered necessary by want of room for a better arrangement. The Female School has been established with a double purpose: it is calculated not only for the improvement of the arts usually practised by females, but some prominence is given to the object of extending as much as possible the resources, hitherto too narrowly limited, for the exercise of female industry. It is considered that the employments open to females, and for which they may be qualified by instruction in the arts of design, may comprise designing and working in embroidery of every description, lace, gimp, fringe, and every sort of worsted work; designs for everything relating to jewellery, engraving, and enamelling in gold, setting stones, false jewellery (which is manufactured in Paris to an immense extent, with great taste and ingenuity), small articles in or-molu, and the burnishing and colouring of metals; fancy works in card and paper, and patterns for the papers employed in them; pictorial toys for children, dissected puzzles, &c.; porcelain painting, in all its branches; lithography, and engraving on copper and wood. And it is to be observed that the *Ecole Communale* is much frequented by females already occupied in such pursuits, who devote their leisure hours to improving themselves in drawing; those engaged in jewellery, artificial flowers, and engraving in gold, resort there in numbers. In order to carry out the intentions of the Government in this respect, the course of instruction in the Female School includes the figure, landscape, animals, flowers, and ornaments. It has been noticed that many of the pupils take up especially the study of the head, the figure, and landscape, with a view to become teachers of drawing; but the course of study followed in the school is not considered to be of a nature to qualify them for this position, which requires that the elementary studies common to all classes of art should be followed up by those peculiar to the higher branches.

"It must be observed, that in this branch of the School at Paris the objects proposed are not yet carried out to their full extent. There are several deficiencies to be supplied; and lithography has not hitherto been taught at all.

"The Provincial Schools in France are not necessarily regulated by that of Paris; and a view of the system pursued at Lyons, where the first of the Provincial Schools has been carried out to its utmost capabilities, with the most successful result in effect upon the peculiar manufactures of the place, cannot fail to be regarded with interest. But the success which has attended the School of Lyons is mainly owing to the appreciation of its importance by the authorities and inhabitants of the city itself, to the energy, with which they have promoted it, and the liberality with which they have contributed to the funds for its support. And I may here notice in evidence of the zeal and intelligence of the manufacturers of Lyons in the pursuit of their commercial interest through the means of industrial art, a memorial lately addressed to the Mayor of Lyons, that, with reference to the new vent for manufactures opened in the East, he should call upon the Minister of Commerce to procure for the manufacturers, by means of the Consuls and other commercial agents, patterns of the oriental stuffs of silk, wool, and cotton, which can be imitated at Lyons; and it is significantly pressed upon the Minister '*that this proceeding should not be left to other nations.*'

"It is a fact worthy of attention, that at the foundation of the School of Lyons the mistake was committed of drawing too distinct a line of demarcation between the elements of *fine art* and those of art as applied to industry and manufactures; and the first course of instruction established in the School was applied to the technical process of the *mise en carte*; this was shortly superseded by a class for '*drawing applicable to manufactures*,' that is to say, to silk manufactures; but as the pupils who attended this class proved to be already advanced in flower painting, the professor found the basis of instruction to which he was confined too narrow to enable him to effect anything essential for their improvement: the course of instruction was therefore made general, by the adoption of a methodic course of ornament, applicable not only to that style of drawing, but to sculpture in wood, metal, and stone. From this period important modifications have been made from time to time in the system of instruction, so that scarcely anything is now left of the original organization of the school. Into these changes no theories have been suffered to intrude—they have all been effected as experience has dictated their necessity, and the result, as is well known, is eminently practical.

"The present course of study pursued in the school is as follows:—the elementary study of the figure, drawing the figure from the round, and from the living model. Hence the pupils enter the classes for drawing and painting flowers, and after passing through the class of architectural ornament (combined with geometry and perspective), finish the course of study obligatory on all who remain in the school by a class of composition applied to manufactures. Thus it will be seen that to *perfect the taste* of designers and manufacturers, for that is the great point to be attained, a sort of inversion of principle is adopted, beginning with the figure, thence passing to flowers, thence to ornament in general, so as to prepare the student with a sound artistical education for finishing with the course of composition peculiar to the silk manufacture. To give instruction in this course, there are ten professors, including one for anatomy, one for etching, one for geometry and perspective, and one especially for flower painting. The annual expense of the establishment amounts to about 40,000 francs, of which 30,000 are supplied by the city, and 10,000 by the Government; but the citizens of Lyons consider all their literary and scientific establishments as intimately connected with their school, and that its success is greatly promoted by the general knowledge diffused among all classes by means of their library, their museums of antiquities and natural history, and other public institutions.

"The school is open five hours every day,—the professors attending from nine o'clock till two in the winter, and from eight to one in the summer. The pupils enter at the age of fourteen. They must be able to read and write, and to do the four rules of arithmetic, and are compelled to follow the whole course of instruction if they remain in the school. They are removed from one class to another on the recommendation of the Professor of their class to the *Council of Professors*. During the first month the pupils draw for the purpose of ascertaining the class in which they are to be placed. Two years' trial are allowed before they are dismissed for incapacity.

"The Director has abolished the use of heads in lithography as studies for the pupils, finding them from their general mediocrity, unfit for the purpose. The frequent competitions at the *Ecole des Beaux Arts*, at Paris for '*têtes d'expression*,' has enabled him to collect a sufficient number of valuable drawings of this class, mostly prize works, from which the pupils now study to the exclusion of engravings. This example is strongly recommended to be adopted in all schools, not only as regards chalk drawings, but also for models, and all other objects of study. The Director greatly desires that casts of the Parthenon marbles may be added to the collection.

"The object of the Government in supporting the Provincial Schools, is to develop art in such a manner as to enable the pupils in quitting them to exercise a profession, each town directing the final studies of the pupils more particularly to its predominant manufacture, and the system upon

which the schools are worked is calculated to direct not only the hand and eye of the pupils, but also their taste. For this result, the study of the figure is found by practical experience to be the most instructive. Geometrical forms alone, though useful to exercise the fingers, are insufficient to give a perception of beauty, and harmony of outline—a fact fully proved by the practice of the School at Toulouse, where the latter mode of study has been substituted for the former. Cold and unmeaning lines convey no intelligence to the pupils, and excite no interest. Hence the pupils who at Toulouse pass from the elementary to the higher classes, are found to be strikingly inferior to those of the same standing at Paris and Lyons. When they come to draw other objects from the round, they are altogether deficient in the knowledge of light and shade, and relief, and even facility of hand. The error which has been experienced at Somerset House seems to have been committed at Toulouse, of confining the study of the figure to a small and select class, the master of which has another class to attend to; so that, to use M. Texier's words, 'the figure has only *half* a Professor allotted to it.' It is therefore proposed, as an improvement of the utmost necessity, that the School of Toulouse should be assimilated, in this respect, to those of Paris and Lyons. A pupil who has followed the elementary study of the figure, with the management of the chalk and stump, is found to possess a knowledge of shadows and reflections, which open to him a thorough understanding of every work in relief before which he may be placed. The School is also deficient in other particulars: the classes sit for two hours only even for the study of the figure—a space of time totally insufficient. There is no class for plants, and the class for demonstrating the composition of ornaments of all dates and styles, described under the Paris School, is much to be desired, not only at Toulouse but at Lyons. There seems to be some difficulty in finding a competent Professor. The Council of Toulouse wish for the establishment of a course of chemistry applicable to manufactures.

"I could have wished to take such a view of the manufactures of Paris as might have enabled me to draw some comparison with those of our own country; but as the time at my disposal did not admit of any general inquiry, I confined myself to the subject of stained glass, of which a great quantity has lately been executed in France. The church of St. Denis has been completely fitted up with modern coloured glass, in a style which it is impossible to commend. Part of this glass is designed on the imbecile principle unhappily too prevalent in England, of imitating the wretched drawing and composition of the middle ages, under the notion that this perversion of art is essential to the character of the work. But the glass of this order at St. Denis is destitute of the archæological knowledge and taste in the arrangement of colour, which are the redeeming quality of many English performances of this class. Other portions of the glass at St. Denis are designed on the still more mistaken system of assimilating glass painting to painting on canvas.

"At the royal manufactory of Sèvres, great pains have been bestowed on the improvement of stained glass. Being, however, doubtful of the impression to be produced by the view of mere specimens, I did not visit Sèvres, but performed a journey to Dreux, about sixty miles from Paris, where a magnificent chapel, designed by the present king as a mausoleum for his family, has been completely fitted up with Sèvres glass. There is much good art in this glass. There are figures and groups, of which the drawing, composition, and expression are extremely fine, but the colouring is in some portions crude, and in others vapid. There is an insufficiency of the detail essential to the proper effect of stained glass. The draperies are too plain. There is an attempt at diaper-work upon some of the backgrounds, but it is feeble and inefficient, and the general effect of the whole is poor. The artists, with all their merit, and it is great, have evidently been hampered by the principles and practice of painting on canvas, and the mechanical process of joining the glass has been so ill understood that all the subjects are cut up into squares by the ironwork. The same observations will apply to the glass in the chapel erected at Paris to the memory of the late Duke of Orleans, also from the Sèvres manufactory.

"The modern glass displayed in the new church of St. Vincent de Paul is of extraordinary quality. In this the artist has solved the problem of uniting high art with the conditions required for the due effect of painting on glass. Fine design, drawing, and expression, combined with a perfect conception of the distribution and collocation of colour, and a profusion of detail in the draperies, background, and borders, render it an example of rare perfection in stained glass, not inferior to the ancient in brilliancy and harmony, and immeasureably beyond it as a work of art. Each window contains a figure, or two, on a blue background, richly diapered, within a border of small figures in compartments, formed by green arabesque. This glass is the work of M. Maréchal, of Metz, an artist also greatly distinguished as a crayon painter. I should consider a fine specimen of his work an important acquisition to our School, if it could be obtained at any price.

"It is probable that some of the facts and observations which I have now had the honour to submit to the Council, may bear upon circumstances connected with our own establishments, and it is not impossible that comparisons may offer themselves during my approaching visit to the Provincial Schools. I have therefore hastened to submit these remarks to the Council whilst they were fresh in my mind, and unbiassed by anything arising in the course of my tour of inspection.

7th Oct. 1845. "AMBROSE POYNTER."

REVIEWS.

Turning and Manipulation. By CHARLES HOLTZAPFFEL, Vol. II. Illustrated by upwards of 700 woodcuts. Holtzapffel. London: 1846. 8vo.

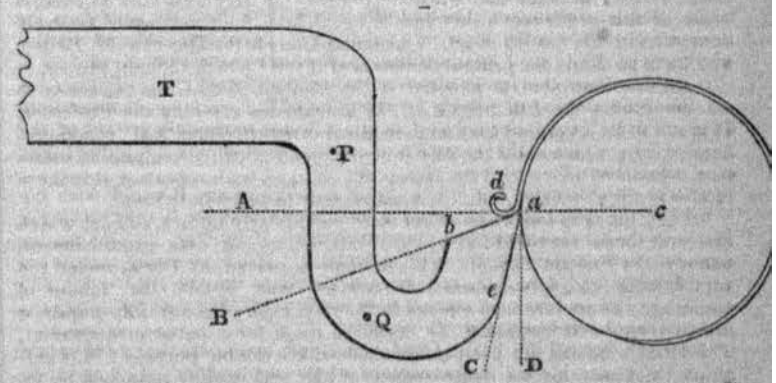
[SECOND NOTICE.]

In the former notice of this interesting work we gave a brief outline of its contents. The volume concludes with an appendix containing papers by several contributors, and additional notices of new processes and inventions which have come to the author's knowledge while the work was passing through the press. The author has directed our attention to the following remarks, which we accidentally overlooked when alluding to the contributions by Prof. Willis.

"The formation of the tools used for turning and planing the metals is a subject of very great importance to the practical engineer, as it is indeed only when the mathematical principles upon which such tools act, are closely followed by the workman, that they produce their best effects. With a full conviction of the advantages which result when theory and practice are thus associated, the author has to congratulate himself on being able to present to his readers, two original papers, respectively written on the subject of the principles of tools for turning and planing metals, by Charles Babbage, Esq., F.R.S., &c., and Professor Willis, A.M., F.R.S., &c., both distinguished by their high mathematical attainments, and their intimate practical experience in the use of tools."

The first paper by Mr. Babbage treats of the nature of the resistance to be overcome in the cutting a revolving substance by means of a fixed tool, and is an admirable instance of the importance of applying general inferences from the theory to the practice of mechanics. Of course it would be impossible to calculate with perfect accuracy the amount of resistance to the progress of the tool, as the material will never be perfectly homogeneous, nor the thickness of the shaving separated from it perfectly uniform. Still in this, as in other instances of the application of theory to practical cases, though the *numerical* results may not be depended upon, the *general* conclusions are of the utmost value. The principles here laid down, by Mr. Babbage, would tend to a considerable modification to the forms of tools, and would probably have this advantage—that the construction of cutting instruments would be made to depend not upon uncertain arbitrary rules, but upon fixed and reasonable laws.

"Steel of various degrees of temper and under various forms, is almost universally employed for cutting metals. Before deciding on the forms of the different tools it is desirable to inquire into the principles on which their cutting edges act, and to assign special names to certain angles on the relations of which to each other, and to the metals upon which they are used, their perfection mainly depends.



In the engraving *c* is a cylinder of steel or other metal, and T is a planing or turning tool acting upon it at the point *a*. A *c* is a horizontal line through the center *c*, and the cutting point *a*. B *a*, is a line passing through the cutting point *a* and along the upper plane *b a*, of the cutting tool T. C *a*, is a line passing through the cutting point *a* and along the front plane *e a*, of the cutting tool. D *a*, is a line from the cutting point *a*, at right angles to the radius *c a*. The angle D *a* C, may be called the *angle of relief*, because by increasing it, the friction of that face of the tool upon the work is diminished. The angle C *a b*, may be called the *angle of the tool*. The angle B *a* A, may be called the *angle of escape*, because the matter cut away by the tool escapes along it.

The forces to be overcome in cutting a thin shaving of metal from a cylinder or from a flat surface are of two kinds,

1st. It is necessary to tear along the whole line of section each atom from the opposite one to which it was attached. The force required for this purpose will obviously be proportioned to the length of the cutting edge of the tool, and dependent on the nature of the metal acted upon. But it will be quite independent of the thickness of the part removed.

2nd. The shaving cut off by the tool must, in order to get out of its way, be bent or even curled round into a spiral. This second force is

often considerable, and when thick cuts are taken, is usually far larger than the former force. If the bending were of small extent, then the force to be exerted would vary as the square of the thickness of the shaving multiplied by some constant, dependent on the nature of the metal operated upon. But the bending very frequently proceeds to such an extent that the shaving itself is broken at very short intervals, and some shavings of iron and steel present a continued series of fractures not quite running through, but yet so complete, that it is impossible even with the most careful annealing to unwind the spiral. This partial severance of the atoms in the shaving itself, will require for its accomplishment a considerable exertion of force. The law by which this force increases with the thickness most probably embraces higher powers than the first and second, and may be assumed thus

$$\text{force} = a + b\,t + c\,t^2 + d\,t^3 +$$

For the present illustration it is unnecessary to consider more terms than those already more particularly explained, namely the constant force, and that which varies as the square of the thickness of the shaving. If therefore t be the thickness of the shaving, and A and B two constants, we shall find amongst the forces required for the separation of the shaving the two terms

$$A + Bt^2$$

where A, and B, depend upon the nature of the metal acted upon. We may learn from this expression, even without being acquainted with the values of the constants A and B, that the force required to remove the same thickness of metal, may vary considerably according to the manner in which it is effected. For example,—if a layer of metal of the thickness of $2\,t$, is to be removed, it may be done at two successive cuts, and the force required will be equal to

$$2\,A + 2\,Bt^2$$

But the same might have been accomplished at one cut, when the force expended would have been

$$A + 4\,Bt^2."$$

The latter quantity always exceeds the former when t^2 exceeds $\frac{A}{2B}$ as the writer shows algebraically. Consequently, when the square of the thickness exceeds half the ratio of A to B, less force is required to effect the operation by two cuts, than by one. And in the same way it may be shown that any number of slices (n) require less force than a single slice of n times the thickness if t^2 exceed $\frac{A}{nB}$.

"The angle of relief should always be very small, because the point a will in that case have its support nearly in a line directly opposed to that force acting upon it.

If a tool either for planing or for turning is defectively formed, or if it is presented to its work in such a manner that it has a tendency to dig into it, then a very small angle of relief, in addition to a long back $a\,e$, will in some measure counteract the defect.

The smaller the angle of the tool, the less will be the force necessary for its use. But this advantage of a small angle is counterbalanced by the weakness which it produces in the support of the cutting point. There is also another disadvantage in making the angle of the tool smaller than the escape of the shaving requires; for the point of the tool being in immediate connection with a smaller mass of metal, will not so quickly get rid of the heat it acquires from the operation of cutting, as it would if it formed part of a larger mass.

The angle of escape A a B is of great importance and it varies with the nature of the material to be acted upon. If this angle is very small the action of the tool is that of scraping rather than of cutting, and the matter removed approaches the form of a powder. If however the material is very flexible and cohesive, in that case shavings may be removed. The angle I have found best for cutting steel is about 27°, but a series of experiments upon this subject is much required.

After the form of the cutting tool is decided upon, the next important point to be considered is the manner of its application. The principle which is usually stated for turning tools is, that the point of the tool should be nearly on a level with the axis of the matter to be turned, or rather that it should be very slightly below it. This rule when applied to the greater number of tools and tool-holders is calculated to mislead. Before applying the correct rule it is necessary to consider in each tool or tool-holder, what is the situation of that point around which the cutting point of the tool will turn when any force is put upon the tool. Let this point be called the center of flexure. Then the correct rule is, that the center of flexure should always be *above* the line joining the center of the work and the cutting point.

On looking at fig. 983, A c is the line joining the cutting point a and the center of the work c. By making the tool weak about Q that point becomes the center on which the point a will bend when any unusual force occurs. On the occurrence of any such unusual force arising from any pin or point of unequal density in the matter cut, the point of the tool a, by bending around the center Q will dig deeper into the work and cause some part of the apparatus to give way or break.

If on the other hand the point P is that around which the point of the tool when resisted tends to turn, then since this point is above the line joining the cutting point and the center of the work, the tendency of the additional strain on the point is to make it sink less deeply into the work, and consequently to relieve itself from the force opposed to it.

Fortunately the position of this point can always be commanded, for it is always possible, by cutting away matter, to make one particular part weak. This is indeed a circumstance too frequently neglected in the construction of machinery. Every piece of mechanism exposed to considerable force is liable to fracture, and it is always desirable to direct it to break at some one particular point if any unexpected strain occurs. In many cases where danger may arise from the interference of the broken part with the rest of the machinery this arrangement is essential. In all cases it is economical, because by making the breaking, if it occur, at a selected spot, provision may be made of duplicate parts and the delay arising from stopping the machine be avoided.

The results of the preceding inquiry would lead to considerable changes in the forms of tools generally used in cutting metals, and as the time employed in taking a cut is nsusally equal whether the shaving be thick or thin, the saving in power by taking thin cuts separately would be accompanied by a considerable expense of time. This however need not be the case if proper tool holders are employed, in conformity with the following several conditions: thus

The tool-holders should be so contrived as to have several cutters successively removing equal cuts.—The cutting edges should be easily adjusted to the work.—The steel of which the cutters are formed should be of the best kind, and after it is once hardened should never again be submitted to that process.—The form and position of the cutter should be such that it may, when broken or blunted, be easily ground, having but one or at the utmost but two faces requiring grinding.—It is desirable that when being ground it should be fixed into some temporary handle, in order that it may always be ground to the same cutting angles.—The cutters should be very securely, but also very simply tightened in their places.—The center of flexure of the cutter should, in turning, be *above* the line joining the center of the work and the cutting point:—whilst in planing the center of flexure should be in *advance* of a line perpendicular at the cutting point to the surface of the work planed. Examples of some tool-holders of this kind will be given subsequently.

The effects of such improved tools would be to diminish greatly the strain put upon lathes and planing machines, and consequently to enable them to turn out better work in the same time and at a less expense of power: whilst the machines themselves so used would retain their adjustments much longer without reparation."

The next paper contains an account of various tool-holders invented by Mr. Babbage. Prof. Willis's papers relate not so much to the mechanical as to the geometrical theory of cutting tools or the relations of their sides and angles, the inclination of the edges required for different metals being assumed to be known. Prof. Willis also describes a new tool-holder invented by him, which Mr. Holtzapffel states to be now generally used in his manufactory.

Among the papers in this appendix one of the most useful is that on the diversity of gauges of wires and sheet metals, &c. Our author compares the different scales of measurement of rod iron, nail rod, rifle tubes, wire, sheet iron, zinc plates, crown-glass, &c.: he shows that the greatest inconvenience arises from the numerous scales, which are perfectly arbitrary, and vary in different manufactories. He has given a table of the values of several of the principal gauges to three places of decimals of an inch, the measures being ascertained by an exceedingly accurate sliding gauge, constructed by himself, and indicating by a vernier the thousandths of an inch. In the following extracts the advantage of a general application of decimal notation to small quantities is admirably illustrated.

Decimal Gages.

"*The remedy proposed to remove the arbitrary incongruous system of gages now used*, is simply and in every one of the cases above referred to, and also in all other requiring minute measures, *to employ the decimal divisions of the inch, and those under their true appellations.*

Thus for most purposes the division of the inch into one hundred parts would be sufficiently minute, and the measures 1. 2. 5. 10. 15 or 100 hundredths, would be also sufficiently impressive to the mind; their quantities might be written down as 1. 2. 5. 10. 15 or 100 hundredths, as the decimal mode of expression might if preferred be safely abandoned, and the method would be abundantly distinct for common use if the word "*Hundredths*" were stamped upon the gage, to show that its numerals denoted hundredths of an inch, quantities which could be easily verified by all.

In practice no difficulty could be seriously felt even without this precaution of marking the gages respectively with the word *Hundredths* or *Thousandths;* as we should not more readily mistake 5 thousandths for 5 hundredths, than we should 5 tenths or half an inch for 5 whole inches, or 5 entire inches for as many feet.

Neither is it to be admitted that no such gages are attainable as may be read of in hundredths or thousandths. The demand would immediately create the supply, and there could be no more difficulty in constructing the gages of the customary forms, with notches made to systematic and *definite* measures, *that may be easily arrived at or tested*, than with their present unsystematic and *arbitrary* measures, *which do not admit of verification.*

Besides, for those who desire to possess them, several very correct deci-

mal gages already exist, amongst which may be cited the decimal sector gages long since recommended, and published by the Society of Arts, Edinburgh, and various sliding gages with veniers some to read off in hundredths, and finer ones in thousandths, of the inch, all of which have been long and constantly used in the author's manufactory.

To these may be added—La Rivière's gage, modified and enlarged from that used for the balance springs of watches amongst the Geneva watchmakers.—Chater and Hayward's gage for sheet metals and glass.—Walker's gage for sheet iron.—Whitworth's micrometer gage and others—which may be severally read off to the thousandth of the inch, and even more minute quantities, and amongst which kinds sufficient choice exists for almost every purpose.

The proposed decimal scheme would introduce one universality of system, intelligible alike to all, instead of the numerous and irregular measures now used, which are but partially and indifferently known and lead to frequent mistakes.

It would give a superior idea of particular magnitude, and enable the theoretical and practical man to proceed with so much more decision in their respective communications.

In conveying verbal or written instructions, the system would be in every way superior to the usual methods, as being almost free from the chance of misunderstanding; more especially as some of the decimal sliding gages are so small as hardly to take up more room in the pocket than an ordinary penknife, and might be therefore continually within reach for reference.

When certain objects are required to be so proportioned as to constitute a series; the intervals between the decimal measures would be far more easily arranged and appreciated, than those of vulgar fractions; and if calculation were referred to, the decimal figures, especially when divested of the decimal point, and the zeros to the right of the same, would be immediately intelligible to the least informed, from being then no more in fact than simple numerals.

Quantities expressed decimally would be more easily written down, and more exactly defined than the compound fractions, such as $\frac{3}{8}$ and $\frac{1}{16}$ of an inch—or than the still more obscure method of $\frac{3}{8}$ of an inch *full* or *bare*, as the case might be; which latter nearly sets all attempts at exactness at defiance.

The smaller aliquot fractions of the inch, such as the $\frac{1}{20}$ $\frac{1}{22}$ $\frac{1}{24}$ $\frac{1}{26}$ $\frac{1}{28}$ $\frac{1}{30}$ &c. of an inch, although in themselves very precise, do not from their nature so readily admit of definition or comparison, as the quantities 2. 3. 4. 5. 6. 7. 8. 9. or 10 hundredths of an inch; because, in the vulgar fractions every one has a *specific* relation to the inch, whereas the decimal terms have one *general* relation, decimals being sometimes considered as the numerators of fractions, all having the constant denominator unity, or 100, 1000, &c.: and therefore the latter, or the decimal terms, constitute a simple arithmetical series, or one in which the intervals are alike, but this is not the case with vulgar fractions.

The decimal scheme would allow the exact weight in every superficial foot of sheet metals and other substances to be readily arrived at.—Thus, as a cubic foot of water weighs 1000 ounces troy, the specific gravities of lead, copper, silver, &c., denote at the same time how many troy ounces are severally contained in one cubic foot of the same. The specific gravity divided by 1200, gives the weight of a plate or film, the one hundredth of an inch thick, and thence a table may be readily computed, *by addition alone*, to show the weight of plates of any thickness in *troy* ounces.

How confusing would it be, if the measures by which broad cloths, linens, cottons, silks, velvets, carpets, and other textile fabrics, are manufactured and sold, were all different, instead of being uniformly the yard measure; and yet this incongruity fully applies to the various articles whose measurements are described under the mystical names of *number*, *size*, *gage*, and other appellations, which assume *different* values in *different* branches of manufacturing art; as for example, in the various kinds of sheet metals, various kinds of wires, in tubes, joiners' screws, and vast numbers of small manufactured articles, the various sizes of which are arbitrarily designated as Nos. 1. 2. 3. 4. &c.

Why not in all these branches of trade, describe every thing measuring $\frac{1}{10}$th of an inch, as No. 10; those of $\frac{3}{10}$ths inch, as No. 30? and then in sets of objects required to be nearly alike, the succeeding numbers could be 31. 32. 33. 34. 35. 36. &c.; or if fewer and wider variations were wanted, the series might be 32. 34. 36. 38. 40. &c.; or else, 35. 40. 45. 50. 55. Every trade could select any portion of the series it might require, both as regards general magnitude, and the greater or less intervals between the sizes, and with the power of adding to, or subtracting from, the scale first selected, as circumstances might suggest.

But there should be one common understanding that the *commercial* numbers or sizes, when different from the measures of the foot-rule, should be always understood to be hundredths of the inch, (in some rare instances thousandths,) as then from the unity of system no confusion or difficulty could possibly arise.

It may be true that some of the proposals having reference to the weights of materials in the superficial foot, the correspondences with foreign measures, and some of the projects principally intended for the purposes of science, may not be required in every-day practice; but still much remains in the system, that in the opinion of the author, would admit of very easy introduction, and most general and satisfactory employment.

In respect to the practical application of the method of decimal divisions, as regards mechanical construction, the author can speak most satisfactorily from some years' experience in his own manufactory, as he has found it to be most readily followed by his workpeople, and also that it has avoided frequent and vexatious misunderstandings, to which, before its adoption he was frequently subjected, from the want of a more minute and specific system of measure, than is afforded by the common foot-rule and wire gages.

Therefore, from conviction of the usefulness and practicability of the decimal system of measures for small quantities, he would most strongly urge its general, or indeed universal, adoption, as above proposed; the more especially as it is a change that would be attended with very little temporary inconvenience or expense, circumstances which greatly retard all attempts at generalization."

We cannot conclude our notice without renewing the expression of approbation of the work. As far as we are aware, the plan of Mr. Holtzapffel's labours is unique: no other similar book has been published, and this is so comprehensive and perspicuous that no other similar book need be desired.

Ancient Architecture described and demonstrated by its Monuments.—L'Architettura antica descritta e dimonstrata coi monumenti. By L. CANINA. Rome, 1834-1844. 9 vols. 8vo. text, and 3 vols. gr. fol. Plates. Price £24.

M. Canina divides the history of ancient architecture into three epochs and classes—the Egyptian, Greek, and Roman—and symbolises this idea by the juxta-position of the pyramids and obelisks of Thebes, the Acropolis of Athens, and the Roman Capitol, represented in the title-page of his splendid atlas. As the personal representatives of these art-periods, the busts of Ramses III. or Sesostris, and those of Pericles and Augustus are depicted. Since the great discoveries of Champoillon and his disciples, never has Egyptian architecture been treated in that deep and consequential detail as in M. Canina's fine work; and he has also the merit of giving the first *chronological account* of Egyptian architectural monuments. The author further assigns the times of the resorting to the different architectural organic improvemements; for instance, the *vault*, derived from the very inscriptions of the monuments—which implies, besides the knowledge of the architect, that of the hieroglyphist and philologist. The next new feature of this excellent work is, that M. Canina considers the architecture of Egypt, and its limitrophs, as the generic and prototype—of which that of the Jews, Assyrians, and Phœnicians is merely derivative and co-generic. To that common source, also, those very ancient monuments of Asia Minor, only lately discovered, are ascribed, whence Greek and Roman art have taken their origin. Going still further, M. Canina unites to Egyptian architecture that of Persia, India, China, and South America, being *all* only the diverse modification of the same prototype, modified according to climateric, national, and social reasons and incitives. This system of uniting art here introduced, is rich in pregnant ideas and views; still, it must be confessed, one difficult to be carried out, both in its technical and historical bearings.

In the portion of the work treating of the structures of Hellas, many most tasteful restorations of those now vanished erections are represented in all their original symmetry. Still, some weighty critics have taken umbrage at the hypæthral form which has been given to some of the finest temples of Greece—for instance, to that of Zeus Parhellenius at Aegina, the Parthenon, the Temple of Jupiter at Olympia, that of Apollo Epicurios at Bessä, of Neptune at Pæstum, &c. This controversial point has occupied much of the attention of architects, and been also dilated upon in the transactions of the Archæological Society of Athens. The opinion that the Greeks left the middle part of the cella—where the figure of the god-image stood, surrounded by valuable votations,—unroofed, or partly so, has been generally received, and M. Canina also adheres to it. Quatremère de Quincy and Wilkins first combated it, and C. Ross* has, of late, again brought it before the public. The main question hinges on the passage of Vitruvius, III. —"Hypoethros vero decastylos est in pronao et postico—*medium* autem sub divo est *sini tecto*, aditusque valvarum ex utraque parte in pronao et portico. Hujus autem exemplar Romae non est, sed Athenis octastylos est in templo Olympio."—This passage is construed by German critics against M. Canina. It is scarcely to be supposed, that the Greeks could leave such beauteous and surprising colossal sculptures as Pallas Athæna of the Parthenon, or the Jupiter Olympius, to be merely illumined by the dim light from the entrance of a cella, without any windows running down the whole length of the walls.

Among the Greek temples, which our author has so beautifully pictured, some omissions have occurred,—unavoidable, perhaps, in so large a work. Amongst these, we may mention that Ionic show-

* Hellenika. 1846. p. 1-39.

temple of Jupiter Parhellenius at Aizani, described by Texier. The department of Roman architecture, as M. Canina's more immediate and autoptic province, is treated with a detail descending into the slightest minutiæ of theory and practice. The great number of 256 plates is devoted to this portion of the work.

Narrative of the Recovery of H. M. S. Gorgon. By ASTLEY COOPER KEY, Commander, R.N. London: Smith, Elder, and Co. 1847. 8vo., pp. 113.

During the military operations of the Buenos Ayrean army against Monte Video, in 1843, a violent gale occurred, by which H. M. steam-ship *Gorgon*, part of the British squadron stationed in the River Plate, was driven ashore. The present work contains a clear, interesting, and most minute account of the mechanical means by which the vessel was rescued from her perilous position. The difficulties contended against were so formidable, and the ingenuity and energy displayed in overcoming them so great, that the account given by an officer of the vessel, who appears to have had an important share in the work, possesses a general interest. To the naval officer and engineer, however, the narrative will appear of much more importance than an interesting story: the accurate and detailed explanation of all the operations and apparratus, and the record of their comparative efficiency, brings this work into that class of circumstantial publications which the two professions have learned to consider invaluable. It may be added that the present moment seems happily chosen for publishing this book, when general attention is attracted to the fate of the *Great Britain*.

Before analysing the part of the work referring to the recovery of the ship, we may be doing some service by calling attention to certain defects of construction, which Lieut. Key assigns as contributing causes of the stranding of the *Gorgon*; they are these—1st, insufficiency of engine-power for extraordinary emergencies; 2nd, the want of anchors and cables in number and size proportioned to those of sailing vessels; 3rd, the absence of a mizen-mast. Under the first head, our author well remarks that a steam ship ought to have power sufficient for extraordinary as well as ordinary occasions. The *Gorgon* had not during the gale sufficient power to steam into deep water, and barely gained steerage way. Again, the sails could not be used to bring the vessel to the wind, for from the position of the mainmast, the effect of the main trysail was neutralised by the action of the wind on the paddle-boxes, which were as much before the centre of the ship as the trysail was abaft it: had there been a mizen-mast, its sail would have had leverage to turn the vessel.

In order to understand the subsequent operations, we must consider the position of the vessel after stranding. She was found on examination after the storm, to have run *head foremost* into a sand bank, 13 feet high. A few feet of her stern were still in the water, but by far the greater part of the ship rested on—and, forward, was imbedded in—the sand. The idea of getting the ship from such a position, without taking her engines out, when first expressed by her commanding officer, Capt. Hotham, subjected him to the pleasant suspicion of labouring under a fit of insanity.

The means of the recovery were mainly these: the formation of a dock by the excavation of the sand for a distance of twenty feet from the vessel; the application of large screws on the beach, partly to raise her vertically and partly to start her forward; the lashing of buoyant caissons to the ship's bottom to lighten her; the haulage by cables attached to the vessel worked by capstans on the beach; and by other cables attached to anchors in deep water, and worked by the ship's engines.

The first of these operations was by far the most arduous, and was continued almost incessantly during the whole time occupied in recovering the vessel—upwards of five months. From the loose nature of the sand and effect of the tides, the banks of the dock frequently gave way, and the labour of a month was undone in a few hours. A great part of the excavations were effected manually, but an ingenious machine, constructed upon the spot, was also used for the same purpose. To a fulcrum on either side of a barge was fixed a long lever, with a capacious mud-bag at the end of it; the mouth of the bag being kept open by a hoop, to which chains were attached to drag it through the sand: the chains were worked by winches in the extremity of the barge. By these simple means, 4½ tons were cleared away in an hour, and the apparatus was sometimes kept in use night and day for several weeks together. The great difficulty however was not to get the mud out, but to keep it out. A resident civil engineer undertook the construction of a dam of piles of three-inch plank, driven *four or five feet* into the sand;—the first high tide carried them all away. Another dam, however, constructed on the starboard side of the vessel, where the water had little force, answered its purpose tolerably well, the piles forming it being driven deeply into the sand. A complete bulwark against incursions of the sand was subsequently constructed by mooring alongside the vessel three large iron boats, which together formed a breakwater 120 feet in length.

The application of pressure by means of large screws to force the vessel forward seems to have been a novel one. The employment of vertical screws in transporting and launching vessels had been already practised, but here for the first time screws were used to propel the ship as well as raise it. Only a limited number of cables could be obtained for hauling, and the aggregate strain which these would bear without breaking was totally inadequate to move the ponderous mass to which they were attached. The application of the screws therefore effected that which without them would have been impracticable. The great difficulty was to obtain a firm purchase for them, as the abutments on the loose foundation, against which they acted, were liable to give way. This difficulty was overcome by imbedding enormous blocks of wood deep in the sand, so as to distribute the back-pressure of the screws over a large surface.

Our author calculates that a force of about 550 tons was applied to start the ship forward—300 tons from the pressure of screws, and the remainder from the tension of cables. The screws were all inclined to the horizontal, so that their force was partly vertical, partly horizontal. The pressure resolved in the former direction was about 130 tons; in addition to this upward force there were 470 tons arising from the buoyancy of large camels, caissons, boilers, tanks, and barrels attached to the ship's bottom; so that the total force tending to raise the ship was about 600 tons. We cannot pursue the narrative further than to state that by these means, after nearly half a year of forethought and invention on the part of the officers, and unceasing industry on the part of the men (nearly 300 in all), the vessel was restored to her native element, without any injury, unless we except the following very trivial one, which we allude to merely because it arose from a cause worthy of the attention of the practical engineer:—

"At one of our previous attempts to move the ship, when no impression could be made on her, beyond giving her a lift to port of about 10°, the sudden heel had fractured the waste water and injection pipes, thereby showing that the ship must be slightly strained somewhere; but, as these pipes are of cast iron and are rigidly bolted to the ship's side, a very slight jerk would be sufficient to break them; soon afterwards, however, when the ship was brought upright by the camels, the broken parts resumed their original position, and so exactly, that the fracture could not be discovered without very minute inspection, and in that state were easily and efficiently repaired; this showed what a trifling strain was sufficient to break these pipes, and it would appear that in the event of a steamer taking the ground under any circumstances, should she not be so strongly built as the *Gorgon*, these vital parts of the engine would be liable to serious injury—surely a remedy for this might readily be found, by fitting these pipes with a sliding joint, and also, instead of bolting the extremities to the ship's side, less liability to fracture would be incurred, by fitting it with a slide and flange, giving the extremity of the pipe free motion in every direction, and making the diameter of the hole in the ship's side, something less than that of the pipe."

The principal practical value of this book arises from the minuteness with which the information is given. There are eighteen lithographic plates, and every piece of apparatus of any importance is carefully delineated and described in a detailed manner. The information respecting admeasurements also is generally complete, and the author seems to possess considerable knowledge of theoretical mechanics.

The Colosseum, St. Peter's, The Pantheon, The Forum; drawn and engraved by DOMENICHO AMICI, Membro d'Onore della Congregazione de Virtuosi al Pantheon. Size 22 inches by 19 inches.

These splendid engravings, illustrative of Rome, have just been imported into this country from Rome, by Messrs. Groombridge and Sons; they are admirably drawn and engraved in the line manner, by Domenicho Amici, an Italian engraver of considerable merit; they are the commencement of a series. The above four prints are well suited to the studio of the architect.

A Practical Treatise on Perspective Simplified. By GEORGE PYNE. Weale, 1846. 12mo. pp. 109. Lithographic plates.

This treatise is addressed to those who wish to acquire only a limited knowledge of perspective, but to acquire that little correctly. The object of the author has been to render the work as concise as possible, and to

omit every superfluous line: he has attained this object, without sacrificing brevity. To those who merely wish to sketch from nature in correct perspective, without attaining the geometrical precision of the architectural draughtsman, this little Manual will be an excellent guide.

The Literary and Scientific Register and Almanack for 1847. By J. W. G. Gutch. This annual is replete with highly useful scientific information.

SIR JOHN SOANE.

For the following memoir we are indebted to the labours of Mr. George Bailey, the able Curator of the Soanean Museum; it was published some time since as an Appendix to a Memoir of Sir John Soane, by Mr. Donaldson, and has now received some trifling corrections to render it more perfect.

1753. September 10, born near Reading.
1768. Entered the office of Mr. George Dance.
1772. Exhibited his first drawing at the fourth exhibition of the Royal Academy, "Front of a nobleman's town-house."
1772. Obtained the silver medal at the R. A. for the best drawing of the front of the Banqueting House at Whitehall.
1774. An unsuccessful competitor for the gold medal at the R. A.
1776. Gained the gold medal for the best design for a triumphal bridge.
1777. Left London for Italy.
1778. His first publication, entitled, "Designs in Architecture," appeared.
1780. Elected member of the Academy of Fine Arts at Parma, and returned to London from Italy in June.
1784. Designed and executed extensive alterations and additions to Mulgrave Hall, near Whitby, Yorkshire, for the Earl of Mulgrave—and to Ryston Hall; designed a house for the Rev. G. Gooch, Norfolk; Tendering Hall, Suffolk, for Admiral Sir Joshua Rowley.
1785-8. Designed a house at Shottisham, near Norwich, for Robert Fellowes, Esq.; Letton Hall, for B. G. Dillingham, Esq.
1788, October 16. Appointed architect and surveyor to the Bank of England.
1788-1794. Designed alterations and additions to Norwich Castle.
1789-90. Rebuilt Blackfriars Bridge, at Norwich; designed and executed extensive additions to Chillington, the seat of Mr. Gifford; designed a house for the Rev. Charles Collyer, Gunthorpe; designed extensive alterations and additions to Bentley Priory, near Stanmore, for the Marquis of Abercorn.
1790-4. Buckingham House, in Pall Mall, for the Marquis of Buckingham, and a town mansion for the Duke of Leeds, in St. James's-square.
1790-9. Designed alterations and additions to Moggerhanger House, Bedfordshire, the seat of Godfrey Thornton, Esq.
1791. Designed extensive alterations and additions to Skelton Castle, for John Wharton, Esq.
1791. Appointed Clerk of the Works to St. James's Palace, the two Houses of Parliament, and other public buildings in Westminster.
1791-2. Designed and executed alterations and additions to Barons Court, in Ireland, a seat of the Marquis of Abercorn.
1791-3. Designed and executed alterations and additions to Wimpole, the seat of the Earl of Hardwicke.
1792. Designed and built his own house, No. 12, Lincoln's-inn-fields.
1792. Designed and executed alterations and additions to Sulby Lodge, Northamptonshire, the seat of René Payne, Esq.
1793. Published a work, entitled, "Sketches in Architecture."
1793-6. Designed and executed Tyringham Hall, near Newport Pagnel, for Wm. Praed, Esq.
1794-1802. Designed and executed a house at Reading, for W. B. Simmonds, Esq.
1794. Designed and executed the entrance gates and lodge in Hyde-park, opposite Great Cumberland-street (since taken down); a house for the Hon. Mrs. Yorke, near Southampton.
1795. Became a member of the Society of Antiquaries; elected Associate of the Royal Academy; appointed architect for new buildings and repairs in the royal parks, woods, and forests, July; designed and executed extensive alterations and additions at Bagden House, for the Earl of Ailesbury.
1796. Designed and executed extensive alterations and additions at Hinton St. George, for Earl Paulett; designed and executed a house at Reading, for L. Austwick, Esq.
1797-9. Designed and executed alterations and additions to Holwood House, the seat of the Right Hon. W. Pitt.
1797-8. Erected a house in Stratton-street, Piccadilly, for Col. Graham; designed and executed alterations and additions to a house for the Countess of Pembroke, Grosvenor-square.
1799. Offered himself candidate for the surveyorship of the East India Company; published a letter to the Earl Spencer, K.G.
1799-1808. Designed and executed extensive alterations and additions to a house in St. James's-square, for Samuel Thornton, Esq.
1800-1. Designed and executed extensive alterations and additions to Aynho, Bucks, the seat of W. R. Cartwright, Esq.
1801. Designed and executed the banking-house in Fleet-street, for Messrs. Praeds and Co.
1802. Elected Royal Academician; designed and executed alterations and additions at Albury Park, the seat of Samuel Thornton, Esq.; ditto, at Cricket Lodge, near Chard, the seat of the Viscount Bridport.
1804. Designed and executed the obelisk in the market-place at Reading, erected at the expense of E. Simeon, Esq.; built a large house, counting-houses, warehouses, &c., in Fountain-court, Aldermanbury, for W. A. Jackson, Esq.; a villa, for himself, at Ealing; designed and executed alterations and additions to Port Eliot, St. Germans, Cornwall, the seat of Lord Eliot, afterwards Earl of St. Germans.
1804-1807. Designed and executed alterations and additions at Ramsey Abbey, Huntingdonshire, the seat of W. H. Fellowes, Esq.
1804-1806. Designed and executed alterations and additions to a house at Roehampton, for John Thomson, Esq.
1805-1819. Designed and executed alterations and additions to a house in St. James's-square, for Lord Eliot, and the Earl of St. Germans.
1805-1806. Designed and executed the Gothic Library, at Stowe House, Bucks.
1806-1807. Alterations and additions to Macartney House, Blackheath, the seat of the Hon. G. F. Lyttleton.
1806. Elected professor of architecture, in the Royal Academy.
1806-1811. Erected a mansion at Moggerhanger, in Bedfordshire, for Stephen Thornton, Esq.
1807. Erected a monumental tomb, in the church-yard, at Leytonstone, in Essex, for Samuel Bosanquet, Esq.; appointed clerk of the works of the Royal Hospital, at Chelsea.
1808. Made designs for the completion of Taymouth Castle, the seat of the Earl of Breadalbane; for the Royal Academical Institution, at Belfast; designed and executed a mausoleum, adjoining the house of Mr. Desenfans, in Charlotte-street, Portland-place.
1808-1810. Designed and executed the five new houses in Princes-street, forming "New Bank Buildings."
1809. Designed and executed the new infirmary, at Chelsea Hospital; 27th March, read the first lecture, Royal Academy.
1810. Repeated the first lecture, Royal Academy, January 8; lectures stopped, at the fourth lecture, on January 29; designed and executed alterations and additions to Whitley Abbey, near Coventry, the seat of the Right Hon. Lord Hood.
1811. Designed and executed the entrance to the London Dock Company House, and to the counting-house of Messrs. Thellusson and Co., in Meeting-house-court, Old Jewry.
1812. January 9, Lectures resumed, Royal Academy; designed and executed a house in Park-lane, for Mr. Robins; alterations and additions to Everton-house, Bedfordshire, the seat of William Astell, Esq.; designed and built his own house, 13, Lincoln's-inn-fields; the New Gallery, at Dulwich College, to receive the collection of pictures, bequeathed by Sir Francis Bourgeois, and a mausoleum, wherein are deposited the remains of Sir F. Bourgeois and Mr. and Mrs. Desenfans.
1813. Elected Grand Superintendent of Works to the United Fraternity of Freemasons.
1813-1815. Designed and built a house for the Rev. G. Monins, at Ringwould, near Deal.
1815. Designed and executed additions to the Earl of Hardwicke's house in St. James's-square; appointed one of the attached architects to the Office of Works.
1816-1817. Designed and built a farm-house, for Thomas Swinnerton, Esq., at Butterton, in Staffordshire.
1818. Designed and executed extensive alterations and additions to the banking-house of Messrs. Grote, Prescott, and Co., in Threadneedle-street.
1818. Alterations and additions to Marden Hall, near Hertford, the seat of George Thornton, Esq.
1818-1819. Designed and built the National Debt Redemption and Life Annuities Office, in the Old Jewry.
1820-1821. Designed and built houses in Regent-street, for Mr. Robins, and others.
1820-22. Designed and superintended the re-building of Wotton House, in Buckinghamshire, the seat of the Marquis of Chandos.
1820-1827. Designed and built the new law courts, at Westminster.
1821. Chosen a Fellow of the Royal Society; designed and executed Pelwall House, near Market Drayton, for Purney Sillitoe, Esq.
1822. Designed and executed a new church at Walworth, in the parish of St. Mary, Newington.
1822-1824. Designed and executed the new Scala Regia, Royal Gallery, and Library, in the House of Lords.
1824. Designed and executed Trinity church, St. Marylebone; a new chapel in the parish of St. Matthew, Bethnal-green.
1824-7. Designed and erected the new offices for the Board of Trade, and the Privy Council offices.
1825. Designed and erected additional committee-rooms, House of Lords.
1826. Designed and erected additional committee-rooms and a new library for the House of Commons; the new grand Masonic Hall, adjoining Freemason's Hall, in Great Queen-street.
1827. Printed for private distribution, "Designs for public and private buildings.

1828. Published "a brief statement of the proceedings respecting the new law courts, at Westminster."

1829-1833. Designed and executed the New State Paper Office in Duke-street, Westminster.

1831. Designed and executed the ante-room to the Sculpture Gallery of Sir Francis Chantry, R. A.; September 21, received the honour of Knighthood from his Majesty King William IV.

1832. Printed for private distribution, a "Description of the house and museum on the north side of Lincoln's-inn-fields."

1833. Oct. 16. Resigned the appointment of Architect to the Bank.

1833. April 20. Procured an Act of Parliament for settling his museum, library, and works of art in Lincoln's-inn-fields, for the benefit of the public.

1835. March. Presented with impressions in bronze, silver, and gold, of a medal, struck in his honour by the architects of England; received a medal from the Société libre des Beaux Arts at Paris; elected member of the Academy of Fine Arts at Vienna.

1836. Elected consigliere corrispondente of the Academy of Fine Arts at Parma; elected honorary member of the Société libre des Beaux Arts, at Paris, December 9.

1837. January 20. Expired at his house in Lincoln's-inn-fields.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

HARBOUR OF OSTIA.

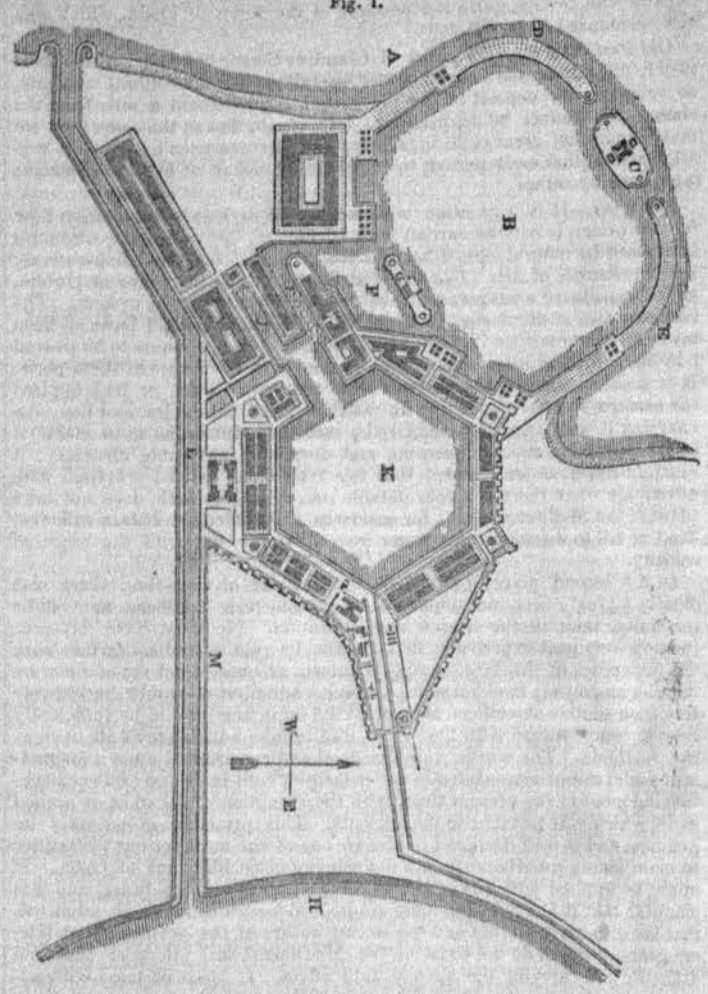
On the Ancient Harbour of Ostia. Paper read at the Institution of Civil Engineers, by Sir John Rennie, *President.*

New Harbour of Ostia.—The river Tiber appears to have been used exclusively as the port of Rome until the reign of the Emperor Claudius, who, conceiving it to be utterly hopeless to improve it against the obstacles of nature, conceived the bold and original idea of making an entirely new port altogether independent of the Tiber. Having once come to this determination, he communicated his views to his engineers, and asked their opinion as to the sum which would be required to carry it into effect; they replied that the sum would be so great that if he knew the amount he would never think of undertaking it. Not at all discouraged by this answer, which, on the contrary, only served to confirm Claudius in his resolution, he ordered the necessary preparations to be made for commencing the work. The situation selected for the new harbour, was a little to the northward of the then mouth of the Tiber, with the entrance pointing N.W., by which means it would be better protected against the southerly and westerly gales, and farther removed from the deposit of alluvial matter brought down by the Tiber; still, however, it was too near to be effectual, for the projection of the new works only served as jetties to check the current along the shore, and thus to occasion the accumulation of a deposit as great as that occurring at the mouth of the Tiber itself. It could hardly, however, be expected that the knowledge of the day was sufficient to enable the engineers to predict all the consequences of this state of things. The effects of the Tiber were evident, and it was naturally concluded, that by abandoning that river, all danger from deposit would be avoided, and it was only by experience that their error was discovered. Accordingly, the Emperor Claudius determined to construct an entirely new harbour, independent of the Tiber, but at the same time having a connexion with it, to be used according to circumstances.

The ancient writers agree generally as to the principles of the design, construction, and extent of the celebrated port of Claudius. The general plan of the harbour is shown in fig. 1. It consisted of an extensive low-water outer harbour, B, and a small inner harbour, F, The outer harbour, B, was formed by two artificial moles, D E, of 1900 feet in length, projecting nearly at right angles from the shore; each mole consisted of two parts or arms; the one nearest to the shore was perfectly straight for about 950 feet, the remainder formed a quadrant of a circle 1800 feet long, the breadth, which was equal throughout the whole length, being 180 feet. Between the outer extremities of the two piers or moles was a distance, C, of about 1100 feet. Immediately in the centre of the entrance, or opening between the two moles, was an isolated or detached mole, 780 feet long and 400 feet wide, forming as it were an island, and leaving an opening at each extremity between it and the opposite pier, or mole, of about 140 feet, thus giving a double entrance to the harbour. The distance between the two piers at the shore, or the total length of the harbour, was about 3000 feet, the width 2330 feet, and the surface extending over about 130 acres; about one-third of this space, however, was excavated out of the main land. Immediately in front of the outer entrance, there was a small inner harbour, F, 1200 feet long and 520 feet wide, covering an area of about 7 acres; this inner harbour was divided from the outer harbour by another isolated or detached mole, G, of the same length as the outer one, with an entrance at each end 120 feet wide.

Immediately behind the harbour were two parallel cuts or canals, H J, communicating both with the Tiber and Mediterranean. The one nearest to the harbour communicated with it at each end of the inner harbour, so that the vessels could proceed either up the Tiber to Rome, or they might go to sea, or in fact might make use of it either for entrance or departure as the wind and other circumstances might be favourable. The other canal was quite independent of the harbour and of the first canal. It was probably used for vessels going direct to Rome, or proceeding to sea without stopping at the harbour. Across both canals there were communicating bridges and probably stop gates, particularly on the one next to the harbour, so that the waters of the Tiber might be turned into the harbour,

Fig. 1.



or be prevented from communicating with it, according as circumstances might render such steps advisable. The lock does not appear to have been then known. The circular part of the northern outer mole was open, or constructed upon arches, so as to give free access to the current, but was at the same time built sufficiently solid to break the sea and produce tranquility within. The circular part of the southern outer mole was solid, to prevent the deposit of the Tiber from entering the harbour. At the extremities of the detached mole, and also of the outer and inner moles, were towers for the purpose of defence, and for drawing strong chains across the entrances, in order to prevent the access and egress of vessels when necessary; thus converting the port into a close harbour (λιμην κλειστος), as used by the Phœnicians at Tyre, and subsequently adopted by the Greeks and Romans. The upper part of the moles was covered with sheds or colonnades, which were used probably for landing goods and for promenades; the interior harbour was surrounded with magazines and warehouses. In the centre of the detached mole, at the entrance to the outer harbour, was placed the great lighthouse, described by Suetonius; the base of which rested upon piles, and was founded by a caisson, formed out of the vessel which brought the great obelisk from Egypt. The depth of this harbour does not appear, but judging from the nature of the coast and the extent to which the piers were carried out into the sea, it could not have been less than from 15 feet to 20 feet, at low water, and that of the inner harbour not less than 8 feet to 10 feet, to have enabled it to accommodate the vessels used at the time.

After the reign of Cladius, the inner harbour was found too small and inconvenient; Trajan therefore enlarged it by making an entirely new inner harbour or basin, K. This was of an hexagonal form, each side being 1160 feet, the diameter being about 1800 feet, and the superficial area being about 70 acres. The entrance between it and the outer harbour was 120 feet in width, and was formed by part of the inner canal made by Claudius to communicate both with his harbour and the Tiber. The remainder of this canal and of the other one by Claudius, was filled up, and a new one, L, nearly parallel to them, was made about 400 feet to 500 feet nearer to the Tiber, communicating with the hexagonal basin, and was no doubt used for the same purpose as the canals of Claudius before mentioned. The inner harbour was also surrounded with quays and storehouses upon

an extensive scale, containing all the requisites for carrying on a considerable trade for the supply of Rome, and for the construction and maintenance of the fleets, which were stationed in this quarter for the protection of the capital, as well as for the purpose of sending expeditions to the various departments of the widely extended Roman Empire. The whole of the harbour was surrounded by an extensive and lofty fortified wall, flanked with towers, quite independent of the town of Ostia, which was also surrounded by a wall.

Old Port filled up.—The port of Claudius Cæsar has now become completely filled up by the alluvial matter brought in by the littoral currents, as well as by the deposit of the Tiber, and is now about a mile from the shore. We cannot be surprised at this result, but at the same time we must admire the great skill, ingenuity, and perseverance by which it was attempted at that early period, to overcome by means of art the obstacles interposed by nature.

Dredging—It is a question well worthy of serious consideration how far this principle may be carried with advantage, or where the obstacles interposed by natural causes become too powerful for the comparatively feeble resources of art. The Clyde at Glasgow, and the Liffey at Dublin, are extraordinary examples of what may be effected by this system. The harbours also of Boulogne, Calais, Dunkerque, and Ostend have all been materially improved in this manner; it still, however, remains to be proved how much further this system can be carried with advantage at these ports. It is doubtful whether the ancients were acquainted with, or had applied the modern system of penning up water in large reservoirs, and then discharging it with increased velocity by means of sluices, so as to enable it to act with more effect in scouring and deepening navigable channels; it must, however, be recollected that this system can only be practised with advantage when there is a considerable rise of tide (which does not take place in the Mediterranean), for otherwise it is difficult to obtain sufficient head or fall to discharge the water from the reservoirs with the required velocity.

In the second place, as regards the harbour of Claudius, there was clearly a great effect, accompanied by considerable boldness, as well as ingenuity, both in the design and execution. He must have foreseen, judging from past experience, that it was in vain to contend farther with the difficulties of the Tiber, and determined at once to get rid of them by making an entirely new harbour, which he anticipated would be entirely free from similar objections, and yet, at the same time, would be sufficiently near to communicate with the Tiber, and to take advantage of its navigation to Rome. The works were designed and constructed upon a magnificent scale, comprising almost every principle, both in design and construction, adopted at the present time, with the exception of the open or arched mole, which was peculiar to the ancients. This principle is certainly ingenious, and is well designed to obviate one of the most serious difficulties in maintaining a harbour upon a flat alluvial coast like that of Ostia. It might be applied with advantage to many cases in modern times, and it is singular that it has not been more studied, although it must be admitted, that the great rise of tide and the stormy nature of the northern seas (circumstances which do not exist in the Mediterranean) interpose practical difficulties in carrying the system into effect. It has been tried with advantage upon a small scale in the outer harbour of Ramsgate, and there are many cases where it might prove equally applicable. The double entrance, when circumstances admit of its being tried, is very valuable, and where it cannot be used, such a particular form of entrance is desirable as would enable vessels under sail to enter and depart at all times; and at the same time would prevent too great an increase of sea. Such a principle was adopted by the late Mr. Rennie at Donaghadee, and was also proposed by him at Kingstown.

The curved form of the outer piers, although well calculated to facilitate the passage of the current, was ill adapted to break the waves; on the contrary, it tended rather to increase their force, particularly at the entrance, where tranquility was much required: the angular form would therefore have answered this purpose better.

Construction.—As regards construction in Ostia, there is an illustration of almost every principle in use at the present time; the rubble thrown promiscuously into the sea to form its own slope, according to specific gravity of the materials and the action of the waves upon them; the solid vertical wall of masonry with arches resting upon piers, founded by means of pozzolano and rubble mixed in caissons; and the caisson and piled foundation for the light-house on the outer detached mole. There is no account of the diving-bell having been applied to the purpose of building under water, but the use of the material pozzolano, which abounds in Italy, was well understood and generally adopted. The mode employed in using it was to mix the pozzolano in a moist state with certain proportions of lime and small pieces of stone, then to throw the whole mass into a dam or caisson, constructed in the form required, and there to leave it until it had set sufficiently hard; the caisson might then be removed, and the mass of concrete left standing, and which became more solid the longer it remained, as the ruins of Caligula's Bridge bear ample testimony. The same system is pursued in many of the ports of Italy at the present day. The French at their new moles at Algiers and Cherbourg, are said to have extended this system with advantage; yet its merits, as compared with masses of natural stone, still require the test of time to prove its superiority.* Vitruvius, in his Chapter on Harbours, especially describes the different modes of operation before mentioned, with repect to rubble, and pozzolano walls, coffer-dams, piling, &c.

From the above account of the ancient port of Ostia, the following general conclusions may be drawn:—

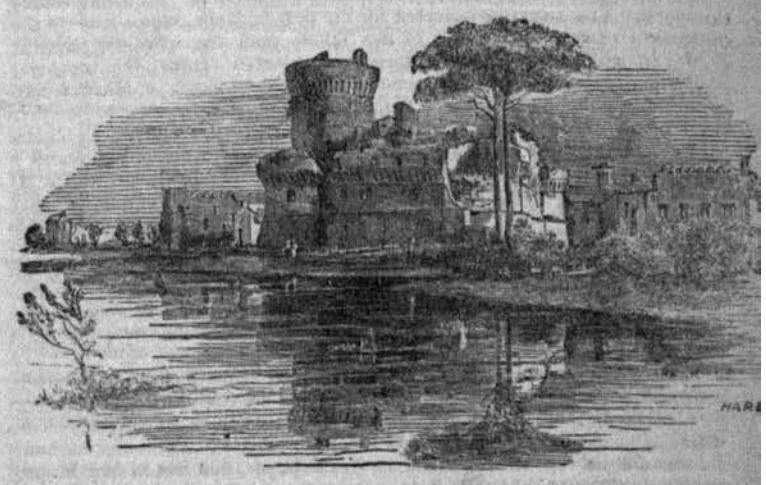
First. That the ancients were well acquainted with the general principles of design and construction of harbours.

Secondly. That as regards the mouth of the Tiber, they carried the improvements as far as was practicable, and that having arrived at that point, their only resource was to construct an entirely new port elsewhere, free from the difficulties by which the Tiber was surrounded.

Thirdly. That in flat alluvial and deeply embayed coasts like those adjacent to the Tiber, it is a matter of the first consequence to ascertain by practical experience, the extent to which the coast line may be expected to advance, from the construction of works at the mouth of a river. This point being first decided, if further improvements be required, then the question of a new harbour free from the difficulties of the old river port may be entertained; and its construction should be so designed as to give the required protection, without incurring the risk of an injurious accumulation of deposit. The port of Claudius, although it was well designed and constructed in itself, was too near the mouth of the Tiber to be effectual, and in fact it acted like a great jetty or continuation of the old works at the mouth of the Tiber; thereby obstructing the free action of the current and producing stagnation on both sides, and by thus, to a certain extent, facilitating the deposit of alluvial matter, which it was intended to obviate, it became overwhelmed and destroyed.

Fourthly. The fate of the port of Claudius and Trajan demonstrated the impracticability of making an effectual harbour near the mouth of the Tiber. Trajan therefore determined to select an entirely new site free from the difficulties of the old, and, with that view, constructed the well known port of Civita Vecchia, anciently called Centum Cellæ, which has been preserved to the present time, a monument of skill and ingenuity in this department of construction. Upon the whole, therefore, the history of the port of Ostia is replete with instruction, as we at once see exemplified nearly all the various departments of harbour construction, both theoretical and practical, together with their usual results, and it is only by a careful study of this and similar examples, combined with a correct knowledge of the various local circumstances, that we can obtain a complete knowledge of this difficult but highly useful and important branch of Civil Engineering.

THE CASTLE OF OSTIA.



[From a Sketch by Mr. Ripingille in 1844.]

Remarks.—After the paper was read, the following observations were made:—

Mr. F. Giles had listened with much interest to the excellent paper which had been read; it was full of instructive, practical facts. He had been forcibly struck with the similarity of the results described, to the effects which were daily under the observation of engineers, in the harbours of the south coast of England. Rye, Dover, and Shoreham, might be quoted as examples. Of the ancient harbour of Rye, scarcely any traces remained. Mr. Giles was sent to Dover by the late Mr. Rennie, during the last year of the Pitt administration, in 1805, with instructions to make a survey, for the purpose of forming an extensive harbour of refuge for the Channel fleet. The design was not proceeded with, but certain improvements were commenced, with the view of removing the mass of shingle on the bar, and preventing a further accumulation. Mr. Walker had since done much for the further improvement of the harbour, by extending the backwater, and affording greater power of scouring by sluices. There was still great room for improvement; and, although there was at present rarely such an accumulation of shingle across the entrance, after a storm, as to close it up, which frequently occurred in former times: yet it was evident, that wherever piers or other obstacles were projected directly from the shore, the shingle would accumulate against them, and turning the point, would be thrown, in the form of a bar, across the entrance. This had become so evident, that the

* Qy Is not Caligula's Bridge a sufficient test of time?—Ed. C. E. & A. Journal.

attention of engineers was now directed to the formation of a harbour of refuge, which must, in his opinion, be detached from the shore, in order to permit the free run of the shingle. Such a harbour, or even a good breakwater, behind which steamers could take shelter, would be extremely useful, particularly in case of war, as from the proximity to the French coast, Dover would require special protection. There were several harbours where, in the course of his practice, Mr. Giles had seen these views exemplied. Bridport harbour consisted of two small piers and open timber jetties, through which the shingle was carried, and was deposited in the entrance. When he was called upon to devise methods of improvement, he directed the open jetties to be filled up with rubble work, and by establishing a system of scouring by sluices, the accumulation was carried away. Shoreham harbour was much in the same state, and in spite of all that had been done, it still remained a bar harbour. The harbour of Sunderland was liable to be choked up with sand, and but for the scour of the river Wear, it could with difficulty be kept open. It, however, was still a bar harbour, and neither in it, nor in any other of the ports that had been mentioned, could vessels be received at low water; in fact, only during the time the tide was up. It would always be observed, that upon coasts which were subject to the shifting of shingle, sand, or mud, any solid projection would inevitably cause effects analogous to those which had been mentioned; and to which might be added, the instances of the works of the harbour of Courtown, County Wexford, commenced by Mr. Nimmo, and continued by Mr. Giles.

Sir JOHN RENNIE, President, said, that the chief object he had in view, in bringing the history of the ancient port of Ostia before the Institution was, independently of the interest which attached to such extensive works, which had failed so entirely from natural causes, to direct the attention of the members to the important question of the effect of the action of tides, and of rivers, in the formation of deltas, shoals, and bars, at the entrances of harbours. Some instances had been given of a few of the English harbours, but the opposite coasts of France and Holland exhibited, in a more marked degree, the effects of this action, not only in the bars of the harbours, but in the formation of banks parallel with the shore. The ports of Dunkerque, Calais, Boulogne, and Havre, might be especially mentioned. In all of them, in spite of continued extension of the jetties, and constant attention to the works, the accumulation of matter at the entrance extended with the new works. Havre was, perhaps, the most extraordinary instance. The current, at the entrance, was at times so strong, that a powerful steam vessel, such as the "Phœnix," had found much difficulty in entering the harbour.

The formation of the Goodwin Sands was a subject of interesting observation. There could not be any doubt of these sands being formed by the action of the eddies of the tide and the river Thames; an attentive study of the position, with respect to the headlands near, the currents of the river and the tidal waters, bearing in mind the direction of the prevailing winds, enabled a reasonable solution of the problem to be arrived at.

Dover harbour was a curious example of the effects of the motion of shingle, which was produced from the débris of the fallen chalk cliff, the flints of which formed the pebbles, and the chalk and earth composed the silt. In the time of Henry VIII., Dover bay was instanced as being very fine, and having very deep water. The prevailing winds caused the shingle and silt to be carried to and fro freely along the shore. As soon as an obstruction was offered by piers, the shingle, having no longer a free and unrestricted course, accumulated across the ends of the piers, forming an embankment enclosing one side of the lake, which was replenished at each tide, until it became so extensive as to burst through the bank, and scoured everything before it. Constant endeavours had been made, and in some instances successfully, to improve the harbour by extending the piers, but, as had been stated, very much yet remained to be done, to form a good harbour at Dover.

It should be remarked particularly in the paper, that one of the leading features in the works at Ostia, was the construction of the moles upon arches, below the line of the low-water mark, so that the moles afforded still water for the vessels, while the arches permitted the alluvial matter to be carried through by the current. The same system had been adopted at Pozzolana, in the mole called Caligula's Bridge, in which concrete was used for the building. Sir John Rennie was of opinion, that this system of construction might be very advantageously adopted in many situations, and he had frequently proposed it. At Carrickfergus he designed two solid breakwaters to keep off the run of the sea on the most exposed side, while from the shore at right angles to it, and pointing to the centre of the breakwater, an arched mole would have been built, besides which vessels would lie, at all times of tide; the run of the shingle along the shore, would thus have been very slightly impeded.

The Italian harbours deserved very particularly the study of engineers. The port of Genoa had been badly designed, and was constantly embarrassed by the deposit in it. Ancona being situated on a promontory had less deposit. At Ravenna the harbour had been nearly destroyed. The port of Venice was almost entirely kept open by dredging by manual labour, assisted by the moderate rise of tide at particular seasons. In the Lagunes, the accumulation of alluvial matter was immense. A canal was constructed entirely round the Lagunes, with locks and sluices, to admit the fresh water when clear, by which means a power for scouring was obtained, and the channel was kept open. Civita Vecchia was principally indebted to its position for being preserved from the alluvial deposit, which was felt so severely all along the coast.

Mr. THOROLD was struck with the apparent similarity between the harbour of Sandwich and that of ancient Ostia, both of which had failed from the same causes; whereas Ramgate was, like Civita Vecchia, an instance of the advantage of a proper selection of a site for a harbour. The port of Dublin might be also instanced as another example of comparative failure; while that at Kingstown was altogether as successful, as he believed it was almost entirely free from sand. The system of scouring away accumulations of sand and silt from harbours, by means of large reservoirs, did not appear to be sufficiently resorted to. Mr. Thorold was of opinion, that in some cases, great advantage would result from the application of the steam engine and the flash wheel, for raising water into the scouring reservoirs. In the fens of Lincolnshire, and near Yarmouth, he had found that arrangement of machinery very economical for draining. It had been applied in the river cutting of the Yarmouth and Norwich railway, after it had been partially filled by a storm. The cutting was about half-a-mile in length, 100 feet wide at the top, and 20 feet in width at the bottom, and was 10 feet in depth. It was completely drained in 36 hours, with an expenditure of only 5 tons of coals. A reservoir of those dimensions would be found a great assistance for scouring a harbour, when any extra accumulation had occurred.

ANCIENT DECORATIVE ART.

At the Archæological Institute was read the following interesting paper on *the various Ancient Decorative Arts and Process of Working in Metals, such as Chasing, Embossing, Niello, Filagree, &c.* By Mr. HUDSON TURNER.

The paper contained rather a general view of the subject than details respecting the several processes in metallurgy anciently used. The writer observed that in the majority of instances we can now show scarcely more than the names whereby numerous artificial processes connected with working in metals during the mediæval period were designated, in evidence of their having been practised. The variety, however, of these distinctive appellations rendered it desirable that a catalogue of the descriptions whereby they were distinguished in commercial traffic should be formed, in order that distinctive names, as yet unintelligible, may be appropriated to the several objects of curious workmanship exhibited from time to time. To the British antiquary it would be an attainment of great interest if his researches enabled him to identify the method of working in gold or silver practised at an early period in this country, and known by reputation in other parts of Europe as the work of England, *opus Anglicum*, and a variety of it familiarly designated as the work of Durham, *opus Dunolmense*. It would be equally desirable to be enabled to classify such examples of foreign workmanship as may be found in our island by their proper designations; as the work of the Saracens, *opus Saracenorum*,—or the *opus Græcum*,—the *opus Veneticum*, work of Venice,—the work of Tours, *opus Turonense*,—or of Cyprus, *opus Cyprense*. Any attempt towards such a classification would possess more than a merely curious antiquarian interest; since it could not fail to throw important light on the history of commerce and international relations in early times. Moreover, the extent to which objects of personal ornament and productions of a costly character were used in a country afforded valuable collateral evidence of the actual state of society. It is obvious that any considerable introduction of foreign luxuries during the infancy of commerce must have been the result of some influential circumstances by which the taste of the time was fixed or modified; and therefore the prevalent esteem for any particular objects of foreign production may be taken as evidence of commercial and friendly relation at that period. The elevation of an ecclesiastic of Greek origin, Theodorus, to the see of Canterbury, in the seventh century, must have tended to the introduction of the arts and choicer productions of Greece or Asia, as well as of the dogmas or ceremonial peculiarities of the Eastern Church: and it was in sacred ornaments that the most costly processes of art were lavishly displayed. The practice of performing pilgrimages to Rome, the Holy Sepulchre, and other remote places—where the rich produce of various countries was displayed to view, and an emporium opened for the supply of the most remote regions of Christian Europe,—doubtless led to the introduction of numerous works of foreign artificers into this country. By such pilgrimages, even more perhaps than by commercial traffic, were the productions of Italy, Greece, or the East, imported into our country in earlier times.

Mr. Turner observed that we have scarcely any data in regard to the actual practising of the more curious processes of metallurgy, either by foreigners or natives, in England, in very early times. It may be reasonably surmised that the most precious existing example of goldsmiths' work—the Alfred Jewel, preserved at Oxford—was fabricated in this country; though some antiquaries consider its enamel as of oriental work, while the gold setting, richly elaborated in filagree, may doubtless be English. However, it was to be remembered that, whilst the art was chiefly subservient to ecclesiastical purposes, it was also chiefly practised by ecclesiastics; and that through their communication with their foreign brethren, the knowledge of curious artistic processes would be diffused throughout their order, and carefully preserved. Thus, the arrival of some Greek acolyte with Archbishop Theodorus affords a reasonable ground for

explaining the introduction of arts into our country which are undoubtedly of oriental character. It was scarcely needful to remind the archæologist that ecclesiastics of the highest grade did not account themselves demeaned by practising the crafts in which they had attained to eminent skill as simple brethren of the convent. St. Dunstan in England, and St. Eloi, bishop of Noyon, in France, who lived at the close of the sixth century, are instances of prelates celebrated for their skill in working the precious metals.

Mr. Turner next adverted to the undoubted practice in Ireland, from a very early period, of the various arts of working in metals. His observations applied not only to productions in gold and silver, but to castings in bronze or mixed metals, presenting the united characteristics of very early fabrication with peculiarities of most skilful workmanship; and he alluded to the superior advantages enjoyed by Irish antiquaries for the prosecution of such an inquiry in the existence of a national collection. The nature and extent of the collection formed by the Royal Irish Academy was known to many members of the Institute, by the series of faithful drawings of the numerous objects preserved in their museum, which, by favour of the Council and the kind intervention of Dr. Todd, were exhibited at the last year's meeting of the Institute at Winchester. It was observable that some of the Irish specimens exhibited a remarkable skill in the use of the metallic compound technically called *niello*, at a period long antecedent to that at which writers have usually accounted that curious art to have been practised. That art, indeed, is of far earlier date than the times of Finiguerra and the Florentine *orfèvres* of the fifteenth century, as is shown by the researches of Count Cicognara, who has given examples of it earlier than the eighth century. In the possession of the Society of Antiquaries there is a Stylus, or pointel, for writing on waxed tablets, the head of which is beautifully ornamented, apparently with *niello*. This little work is of early Norman, or possibly Saxon, date. After some remarks on the art of engraving as applied to the enrichment of sepulchral memorial familiarly termed "Brasses,"—which, independently of their value as family memorials, evidences of costume, &c., possess additional interest as examples of design, and of a peculiar kind of artistic method in the working of metals, viz., the combination of the work of the burin with the use of enamel, and of a coarse assimilation to the process of the use of *niello*,—Mr. Turner observed, he regretted that it was at present impracticable to offer any definitions of a precise nature in regard to many of the mediæval terms to which he had occasion to advert. As respected the distinctive term *opus Anglicum*, by which the works of the early metallurgists of England were known abroad, he ventured to express an opinion that the phrase was not applied to denote any particular process of art, but was rather used to describe the general character and design of the objects fabricated in the precious metals in this country at an early period. And it might possibly have reference to the two peculiar patterns generally worked on the surface of such objects,—which may be broadly distinguished as the ribbon and the lacertine or dragon pattern. The *opus Dunolmense* he was inclined to consider as a peculiar decorative process which the monks of Durham, to whose skill it must be attributed, derived from their predecessors who came from Lindisfarne; and the characteristics of this style were probably analogous to those of the early Irish works to which previous reference had been made. The want of any national Museum of Mediæval Art in this country was a serious obstacle to the prosecution of researches of this nature; as it was only by actual and careful comparison of examples that any satisfactory knowledge of their date or origin could be obtained. In many instances, doubtless, these terms were confounded; as, for example, works of oriental character may have been called without strict regard to their proper designations. But unquestionably these were appellations denoting objects of perfectly distinct style, in their true signification: and, Mr. Turner remarked, that in formal documents some attempt seemed to be made to distinguish the country of objects of price with precision. Thus, in a list of presents (xenia) given to Henry the Third by the Master of the Temple beyond Sea, we find, among other productions of oriental skill—"two *Turkish* bows with strings of leather," and "two iron maces of *Saracenic* work." The discrimination between Turkish and Saracenic work is curious in more respects than one; and, besides its indicating a knowledge of the difference between the races, it would appear to mark some distinction fully recognised in the thirteenth century in the character of eastern productions. By the writers of romance these terms were doubtless used in a more vague or general sense; as in the "Tale of Gawayn," written in the times of Richard the Second, in which the battle-axe of the Green Knight is minutely described, with its handle strengthened with iron wound around it,—

—and all bigraven with grene in
Grecous werkes.

At the same time, the frequent allusion to Greece as the source whence such decorations were derived, is fully consistent with the fact that the chief source of a great variety of artistic processes, of every kind, prevalent during the Middle Ages, may be traced to Constantinople.

In illustration of the goldsmiths' work of the 13th and 14th centuries, Mr. Turner read numerous extracts from the unpublished accounts of the native artists employed by Henry the Third and Edward the First, which showed the variety and elaborate character of the objects executed by them in the precious metals, during those times. In the course of some concluding, and necessarily hasty, remarks on early iron-work, Mr Turner called especial attention to a beautiful cast, exhibited by Mr. Willement, of the wrought iron screen which formerly enclosed the monument of Eleanor, consort of Edward the First, in Westminster Abbey. This beautiful specimen of the iron work of the 14th century was removed but a few years since, and is now rusting in the vaults or crypts of the Abbey. In Mr. Willement's opinion, it is scarcely inferior in beauty to the celebrated work at Notre Dame: and Mr. Turner observed, it should possess great interest in the eyes of English archæologists, as he had discovered that it was the undoubted work of an English smith, one Adam de Leighton, of Leighton Buzzard, in Bedfordshire; who received 12*l.* for the entire fabric—equal to 180*l.* of the present currency. It is to be hoped that under the auspices of the present Dean this remarkable specimen of the excellent craft of a provincial smith in the old time may be either restored to its original position, or preserved from further possible mutilation or decay.

DECORATION OF THEATRES.

At a meeting of the Decorative Society, a paper "*On the Decoration of Theatres*," by Mr. Dwyer, was read. It was illustrated by sketches from the interiors of the Metropolitan Theatres.

The subject was introduced by observations upon the influence which dramatic art and its literature have had for good purposes when judiciously conveyed. The just appreciation of the beautiful in scenic effects, now frequently displayed in our theatres, was adverted to. Mr. Dwyer considered that the best means of increasing the importance of theatres, and raising them in the public estimation, is to render them *magnificently* worthy, in every way, for the dissemination of moral truths and refinements. He noticed the construction of theatres; and admitting that accommodation for the greatest number in the least possible space, with subdivisions for various classes of visitors, formed an important requirement, he argued that the form generally adopted (that of the horse-shoe) is not the most suitable. He maintained that the idea of making the audience feel as comfortably seated in a theatre as in a drawing room had been imperfectly contemplated; and that, however much a curved side might with propriety be admired, *utility* should have the first attention, so as not to restrict the view in any case to merely a portion of the opposite boxes. The circular and semi-circular forms employed by the ancients, Mr. Dwyer said, suggested a useful modification, somewhat approached in the plan of Drury Lane Theatre, and contrasting favourably with the straight-sided horse-shoe form in Covent Garden.

An ignorance of acoustics was said to be evident in the construction of our theatres. Mr. Dwyer referred to several well-known forms, such as tunnels, archways, and long curved spaces; as also to the stone-canopied seats on Westminster Bridge,—where the slightest whisper in one could be heard in the opposite,—as so suggestive that he could not but feel the greatest surprise at such repeated blunders. The proscenium to each of the London theatres was said to be different in arrangement; no two being alike, and none exhibiting an approach to any principle which the laws affecting sound would dictate. Some censure followed on the prevailing use of massive Greek entablatures, with Corinthian columns in unusual proportions (at Astley's very lofty, at the Haymarket very short), exhibiting a disregard of harmony in form and proportion, from the entire absence of a medium for combining the gigantic massiveness in the one with the subdivision of parts throughout the interior of the house. The theatre at Versailles was referred to as an instance where Corinthian columns being placed on the stage, Ionic columns support the superstructure; and which, together with some other arrangements, render this theatre particularly worthy of observation. Nevertheless, the proscenium there is imperfectly constructed for the distribution of sound. Mr. Dwyer considered the upper portion of the proscenium at Covent Garden the least objectionable of any in the metropolitan theatres; and awarded praise to the picturesque and agreeable manner in which it blends with the interior, and also as being in that part better calculated for the distribution of sound. A form of construction was then explained, which, it was said, would obviate the necessity for extraordinary exertions on the part of the performers in attempting to produce an audible and satisfactory effect throughout the house. Mr. Dwyer propounded a theory which, he said, comprehended the principles embodied in two familiar instruments of sound;—viz., the bell and the violin. He said he would construct two bold bell-shaped curves, diverging over not less than eight feet on the stage to the sides of the theatre; each composed of two thicknesses of wood placed about six inches apart. The front one should be perforated ornamentally; thus serving to receive and distribute equally within itself the sounds given forth near to it. The elevation should assume the form of an arch, with spandrels also perforated—thereby distributing with distinct resonance the words or music to all parts of the house.—In a subsequent part of the paper Mr. Dwyer offered some remarks upon the construction of ceilings; which we report now, as having more immediate connexion with the acoustic theory last described. He proposed the use of a spherical or a spheroidal roof, supported by iron ribs, which might be ornamented; the spaces between each rib to be enriched with elaborate perforations (or otherwise, according to the general style of the house), in a manner similar to the doorway in the circle at Astley's. The additional height thus given to the interior would enable the chandelier to be placed above the line of sight from the upper part of the theatre to the stage; and the objections that might be made to this position of the chandelier were met by the fact that a concave surface re-

flects much more than a flat one. Another important advantage arising from this form of ceiling was the facility afforded for a powerful system of ventilation. The painting-room would be raised some nine feet; and the absence of the rolls of canvas, scenery, and other properties, from the top of the ceiling, would add considerably to the reverberation of sounds—besides contributing greatly to the comfort and health of the artists employed in the theatre. Mr. Dwyer elucidated his ideas by sketches. Adverting to the general principles of construction exhibited in the theatres of the metropolis, Mr. Dwyer considered that the Surrey Theatre embraces more than any other the best arrangements for seeing and hearing; the proscenium being formed on a bold level, judiciously diminishing the width of the stage.

The disregard of unity in the construction of theatres generally was pointed out; and, among other instances the St. James's was named—where light flowing ornaments, in the French style, are in juxta-position with a massive Classic style; and the ceiling of the Princess's was deemed an instance of discordant arrangement. The application of various decorative materials, such as distemper paintings, paper-hangings, composition, papier maché, to the fittings, &c., received attention: and it was asserted that the Princess's was conspicuous for elaborate richness and diversity of ornament,—but that it was questionable whether the Herculean expression therein, rather than the grace and delicacy of Apollo, may be deemed appropriate. Mr. Dwyer said, that as a specimen of decoration it merited warm praise; owing to the characteristic vigour throughout every part (*up to the ceiling*), as well as for a suitable strength and richness of colour. The usual enrichment on the fronts of boxes was commented on; and the use of bas-relief, or raised ornament, recommended in preference to the most elaborate surface-painting on panels,—as exhibited at the Italian Opera House, where the effect partakes of the weakness peculiar to paper-hangings and similar media. The second tier in the Princess's was alluded to as a good specimen of this manner; being decided in character, with the details effective but subordinate, and the terminal figures between the compartments skilfully devised. The velvet valances to the boxes in this theatre were commended; but the practice of having them, as in several theatres, to extend only above the private boxes was deprecated. When it is not wished to have ornament in relief upon the fronts of the boxes, valances of this kind suspended from the cushion were suggested as imparting a peculiar and good effect. Ornamental iron-work, is was said, may be introduced with great diversity of design, for balconies, open fronts to the boxes, fret-work and ornaments in relief for various parts of a theatre. Some remarks were added on the usual method of supporting the boxes by series of columns; and others condemnatory of the manner in which the tiers of stage boxes are generally placed *between large Corinthian columns*. Sculpture was mentioned as offering an important adjunct in producing a higher class of decorations,—and encaustic painting as facilitating cleanliness and durability.

At the following meeting some observations on the paper were made by Mr. COOPER; in which, referring to the remarks on a plan of a theatre, he suggested that another form offered considerable, and probably greater, advantages. This he described as the oval; which he would have divided by its longer diameter, one half apportioned to the audience, and the other to the stage, &c. He alluded to several continental theatres, approaching to this form in construction—the Circus Franconi, Napoleon's grand amphitheatre at Milan, the Roman Circus at Verona, and the Colosseum. As painted or shifting scenery was not employed with the Greek Drama, the proscenium was richly decorated with ranges of marble columns, statues, gilding, and bronze. The advantages of the semi-circular and semi elliptical over those of the horse-shoe form were enlarged upon; and the Olympic Theatre at Vicenza, built by Palladio, was said to exhibit them in a perfect manner. This theatre may be considered the *chef-d'œuvre* of Palladio; and was erected, by order of the Olympic Academy of Vicenza—whose members directed him to build it in accordance with the ancient plan, that they might afford their compatriots an idea of the magnificence of ancient theatrical exhibitions. Various plans, as well as the proscenium, which is a remarkably elaborate architectural composition, were exhibited in an old work upon the public and palatial buildings of Vicenza. Mr. Cooper then noticed the remarks by Mr. Dwyer on decorations: several of which met with his concurrence—and others he extended by additional descriptions and suggestions; referring especially to the decorations of the *Théâtre Comédie* at Paris, as of a chaste and appropriate kind. The details were said to be very light, and in the Renaissance style.—The discussion was supported by Messrs. Parris, Seddon, Crabb and others: and the following observations are selected from others of interest. A spheroidal form of ceiling, it was admitted, offered several advantages; influencing ventilation and lighting, as well as contributing much towards a picturesque and pleasing effect.—The decorations of the ceiling in the Italian Opera House, it was observed, had been copied from one in the Ducal Palace at Mantua (a coloured plate was exhibited from Gruner's work), but they had not been successfully adapted. It was considered questionable if the example was suitable for such an extensive surface; if, admitting the propriety of selection, the figures hold their just proportions. The great distance at which they are required to be seen had not been sufficiently regarded in the colouring; and the peculiar haze to the atmosphere in a large theatre, as well as some other general principles in colouring, demanded a different treatment. The use of bright colours, such as vermillion, it was remarked, ought to be restricted to a very limited application.—Mr. Parris supported this opinion by references to works by Raffaelle and Rembrandt; and recommended Indian red and Venetian red, when supported by a bold mass of shadow, as producing a more powerful effect. He also objected to the prevalent use of bright colours for interior decorations—from their harsh and, owing to the general absence of green, fatiguing impression. It was remarked that the decorations of the Italian Opera House appear most satisfactory when the seats are vacant; and consequently, that the design does not embrace some essential principles. The box tiers on the rising of the curtain were compared to bands of white ribbon figured with certain dark spots, oddly associating with the rich scenery and dresses on the stage. Encaustic painting was alluded to; and its durability and effect were said to have been proved equal to fresco when subject to the influence of gas and vitiated atmospheres. Coloured decorations when composed of sprawling cupids or allegories were slightingly mentioned. Some suggestions were made stating that rich fabrics, coloured as Persian carpets, cloth of gold, &c., when thrown over the fronts of the boxes, would conduce to a rich and gay appearance quite distinct from any obtainable by painting.—The *Opéra Comique* at Paris was described by way of contrast to the decorations of our Opera House. A satisfactory, quiet, yet rich effect, it was said, is there displayed, together with some important matters in construction. The ornaments are composed of stamped brass.—A description was given of Covent Garden Theatre as it was when first opened. It was designed by Smirke, and painted under his directions. The drop-scene was painted by William Dixon in subdued colours; with sienna columns and statuary, with broad masses of shadow, conducing to a forcible impression by powerfully enhancing the effect of colours in scenery and dresses on the stage. The repose conveyed on the fall of the curtain was said to have been agreeable, although splendour was not aimed at.

SOCIETY OF ARTS, LONDON.

Dec. 16.—Dr. ROGET, Sec. R.S., V.P., in the Chair.

The Secretary read an address from the Council, which gave a retrospect of the proceedings of the past year, and the proposals of the Council for the future. It stated that formerly the Society, as is well known, stood alone as the great active scientific, mechanical, and artistic society of London, the Royal Society being the only other in any analogous position. That now, however, that great field is happily full of co-operating Societies, each labouring on some one subject formerly a mere dependant on its vast territory. That this removal from the parent Society of so many branches, has necessarily stripped it of many of its bright ornaments; but it appears to the Council, that far from being regarded as an evil, this multiplication of useful Societies is a subject for congratulation, and should be regarded as one strong proof of its past usefulness.

The Council consider that the field on which the Society might with best effect concentrate its future labours, as well as that which most properly belongs to it, is a department of the Fine Arts hitherto much neglected in this country, and which has been strongly approved of by H.R.H. Prince Albert, President of this Society,—namely, that of promoting high art in connection with the mechanical, for which our manufacturers are so justly celebrated.

The Address then proceeded to state the various alterations and improvements which had been effected on the Society's premises during the recess, and concluded with a list of the various pecuniary and honorary rewards about to be offered for competition during the current session.

The first paper read was "*On the principles employed in the recent Decorations of the Society's Great Room.*" By D. R. HAY, Esq.

The paper commenced by stating that the decorator who has been intrusted with the embellishment of the hall of a Society which has for its object the advancement of the ornamental and useful arts, naturally felt much anxiety as to the result of his labours; and this anxiety was increased by the reflection, that his work must necessarily be of a nature calculated to accompany one of the greatest efforts in high art of which this country can boast. His first object, therefore, has been to adopt such a style of decoration as should not only embellish the hall, but at the same time give additional effect to those great works of art which it contains, connecting the whole in one general harmony of form and colour.

This has been effected by surrounding the pictures, by Barry, with cloth of a deep purple hue, which colour is the most effectual in giving clearness to works of high art. The spaces of wall which surround the pictures thus have the effect of being in shade, while the pictures themselves will appear in full light.

Having in some measure separated the pictures from the ceiling, the next consideration of the decorator was the general effect of the hall itself. It is requisite that all apartments, in which great works of art are exhibited, should possess a certain degree of grandeur. This is sometimes imparted by architectural decoration alone; but in the Society's hall scarcely anything of the kind exists. The wall terminates by a narrow and lightly enriched cornice, surmounted by a plain cove of 8 ft. 4 in. wide—this cove is terminated by a narrow border of stucco work, between which and the aperture for the cupola light there is a flat space also quite plain. The aperture towards the cupola light is thrown into eight panels by a plain narrow moulding, and this completes the architectural decoration.

It, therefore, appeared to the decorator that whatever grandeur was to be

imparted to the hall must depend upon the embellishment of the plain surfaces, and that the architectural decorations could only be made to appear as bands dividing those surfaces. It became, however, requisite to unite in some measure the cornice with the walls, and this has been effected by painting it of an Etruscan brown, or deep *terra cotta* hue, which hue forms a natural harmony with the colour of the cloth upon the walls. The plain surface of the cove which surmounts the cornice, afforded the decorator the first field upon which he could exhibit a style of decoration, and this he has confined to a simple combination of geometric with chromatic harmony; and that it might have a *rationale*, he has made this combination to represent mosaic work composed of *giallo antico*, *rosso antico*, *lapis lazuli*, and inlaid gold. This selection of material has a double advantage, for while it gives meaning it also affords an opportunity of using what artists term broken colours, the *giallo antico* being yellow intermixed with tints of purple, the *rosso antico* being a low tone of red, broken up by tints of grey and white, and the *lapis lazuli* being intense blue, likewise broken with tints of gold colour and grey; thus preventing the crude effect of plain patches of colour, and giving the qualities of unity and continuity amongst the parts. The band of stucco work which divides this cove from the flat part of the ceiling is painted pure white, to represent statuary marble, as are also the mouldings round and upon the aperture that leads to the cupola light. This was adopted in preference to the *terra cotta* colour of the cornice, as being equally appropriate and more light in effect. The flat part of the ceiling is also enriched by a mosaic work of a similar chromatic harmony of the same marbles, but of a different harmony of form from that of the cove, and without gold. The panels in the space leading to the cupola are similarly enriched by a mosaic work, composed of *lapis lazuli* and *siena* combined with inlaid gold.

The figures forming the design in the cove are produced by the combination of elliptic bands round central points, so that they are all perfectly curvilinear, and formed by arcs of the same ellipse, the size of which was proportional to that of the principal figures in the pictures. As a contrast to this arrangement of curvilinear forms in the cove, the decorator has introduced a rectilinear design upon the flat part of the ceiling which divides the cove from the cupola. This design arises out of a combination of equilateral triangles producing hexagonal and rhomboid figures, into the former of which the national emblems—the rose, the thistle, and the shamrock—are introduced as if inlaid in *rosso antico* marble. In the panels above this, and forming the sides and spandrils of the space below the cupola-light, the design is produced by the combination of an equilateral triangle and a circle; thus uniting the curve with the straight line, as an appropriate winding up of the linear harmony.

In the centre of each of the four side panels, a shield has been inserted. The one over the chair is blazoned with the royal arms. The shield opposite to the chair is blazoned with the family arms of H.R.H. the President of the Society. The shield on the right of the chair, is emblazoned with the arms of Barry the painter, and that on the left, with the badge of the Society.

The second paper read was "*On the first principles of Symmetrical Beauty, and their application in certain branches of the Art of Design.*" By D. R. Hay, Esq.

This paper commenced by stating that the first principles of symmetrical beauty originate in the power of numbers, and that a means of applying the principle of numbers in the formation of plane figures is afforded by the division of the circumference of the circle into 360 degrees, which degrees are again divisible and subdivisible by 60 into minutes, seconds, &c. Thus, the abstract principle of harmony and proportion in the relations of certain numbers to each other, becomes apparent and visible in their application to the structure of geometrical figures by means of the division of the circle. It then proceeds to show, that to apply these degrees to rectilinear plane figures, each figure must be reduced to its primary element; that the triangle, which is half of the square, is the first and most simple of its class, and is the representative of the No. 2; that the scalene triangle, which is half of the equilateral triangle, is in like manner the representative of No. 3; that the next scalene triangle which arises naturally in the series is that which is half of one of the five isosceles triangle which form the pentagon, and is the representative of No. 5.

We have, therefore, in the square, the equilateral triangle and the pentagon, the primary elements of all symmetrical beauty, as represented by plane figures, and evolving the operation of the harmonic numbers of 2, 3, and 5. Out of the primary rectilinear figures already referred to, arises a second class, as, when an equilateral triange is divided into two scalene triangles by a line drawn through one of its angles and bisecting the opposite side, these scalene triangles, if reunited by their hypothenuses instead of their longest sides, will form an oblong rectangle—every rectilinear figure having its corresponding curvilinear figure.

The paper concluded by showing the operation of the principles of harmonic ratio in the formation of the mouldings of Grecian architecture, ornamental vases, household utensils, &c.

Dec. 23.—W. H. Bodkin, Esq., M.P., V.P., in the Chair.

The first communication read was by Dr. Roget, Sec. R.S., "*On his Economical Chess-Board,*" the object of which is to give the chess-players a board of sufficiently small dimensions to admit of being put into the pocket, when folded, at any part of the game, without deranging the position of the men on the board, so that when it is reopened they will be found in the same place as before, and the game or problem can be resumed where it had been left off.

The second communication read was "*On the effects of Heavy Discharges of Atmospheric Electricity, as exemplified in the Storms of* 1846 (*including an Account of the Destruction of St. George's Church, at Leicester, on the* 1st *of August*); *with Remarks on the Use and Application of Lightning Conductors.*" By E. Highton, Esq., C.E., Telegraphic Engineer to the North Western Railway. Fragments of the roof of St. George's Church, and the apparatus used for getting rid of the injurious effects of lightning on electric telegraphs were exhibited in illustration of the subject. The author commenced by stating that the frequent occurrence of thunder storms during the past summer had afforded almost unequalled opportunities of investigating the effects of atmospheric electricity in the concentrated form of lightning. He then proceeded to give a description of the effects produced on St. George's Church, Leicester, by a discharge of lightning. The church, which was a new and handsome building, was entirely destroyed by the effects of the thunder storm of the 1st of August: the steeple having been burst asunder, parts of it were blown to a distance of 30 feet in every direction, while the vane rod and top part of the spire fell perpendicularly down, carrying with it every floor in the tower, the bells, and the works of the clock. The falling mass was not arrested until it arrived on the ground, under which was a strong brick arch, and this also was broken by the blow. The gutters and ridge covering were torn up, and the pipes used to convey the water from the roof were blown to pieces. The author next proceeded to compare the power developed in the discharge of the lightning which destroyed St. George's Church with some known mechanical force. He stated that 100 tons of stone were blown down a distance of 30 feet in three seconds, and consequently a 12,220 horse-power engine would have been required to resist the effects of this single flash. In the course of the paper the author exhibited the effects of a new battery, constructed by himself, and which was less than the $\frac{1}{40}$ of a cubic inch in size. This battery, he had found, would for a month together ring a telegraphic bell 10 miles off. He also exhibited a second battery, which, although so small that it would pass through the eye of a needle, is of power sufficient to work a telegraph. Having detailed the course of several discharges of atmospheric electricity, he then proceeded to show the effects produced on the electric telegraphs, and the means which have since been adopted to prevent injury to them in future.

M. Highton further stated that since the occurrence of the above storms he had examined the cathedral of St. Paul's, in London, to ascertain how far this noble pile of building is protected from the effects of lightning. He found that the two small turrets have lightning conductors erected, but the central dome has none. He found, however, that the position of the spouts and other metallic connections is such, that he considers if the same are preserved as they now are, the building will, for years to come, be free from damage by lightning; but should they be removed at any time, and glass or porcelain be employed in their stead, then the main part of that noble building would be in constant danger from every storm that passes over the city.

He then concluded by urging the importance of a correct and systematic principle being acted on in the new Houses of Parliament, with a view to securing them from the disastrous effects of lightning.

ROYAL SCOTTISH SOCIETY OF ARTS.

Nov. 23, 1846.—David Maclagan, M.D., F.R.S.E., President, in the Chair.

The following communications were made:—

1. *On producing White, or Neutral Light, by means of ordinary artificial light.* By George Tait, Esq., Advocate, Vice-President.

The white light, or artificial day-light, was exhibited, in contrast with ordinary artificial light, upon the primary and the secondary colours, and upon a coloured sketch.

In this communication Mr. Tait shows, that, while the white light of the sun is composed of rays producing orange and of those producing blue, in equal parts, in ordinary artificial light the rays producing orange exceed by many times those producing blue; the consequence of which is, that the latter light resolves into an orange light a little modified by blue, which affects very much the appearance of the colours of objects exposed to it. In order to produce white light, he incloses the ordinary light in a lantern, or otherwise, and transmits it through coloured glass, or painted glass, of the proper depth of blue, so as to absorb the excess of orange; by which means it is produced at five or six times the expense of the same quantity of the ordinary light employed, which, by using a gas argand lamp, is about a half of the expense of ordinary light from tallow candles. He ascertains the proper tint for the glass by colouring it so that white paper receiving the light transmitted through it may be in unison with similar paper receiving the white light of the sun. He exhibited in a simple and striking manner the great contrast of the effect of ordinary light and of that of white light, or artificial day-light, thus produced by him (by means of glass which he had painted with "French blue") upon white, the primary and the secondary colours, and also upon coloured landscape sketches.

2. Description of a *Patent Safety-Rein.* By Mr. ALEXANDER MILLER, saddler, Edinburgh.—By this rein, which has been a considerable time in use, and severely tested, Mr. Miller states that all possibility of a horse running off is effectually prevented. Its effect when drawn is to compress the horse's windpipe, and thus render him powerless. A vicious horse once or twice checked by this rein is completely under command and learns obedience.

3. Description of a very cheap and convenient *Coil-Electrical Machine.* By Mr. ALEXANDER BROWN. Communicated by George Wilson, M.D. Dr. Wilson, in bringing forward this machine, did so not as claiming a different arrangement from the coil-electrical machines already in use, but he considered Mr. Brown had great merit in making his machine not only convenient in size and handsome in appearance, but very moderate in price. It can be sold at 1*l.* 15*s.*, and is fitted for all medical purposes. The shock can be graduated from the slightest to the strongest, by withdrawing and again gradually introducing the bundle of wire into the centre of the coil.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Dec. 14.—S. ANGELL, V.P., in the Chair.

M. LESUEUR, of Paris, was elected an honorary member.

Drawings were exhibited to illustrate the description of the mode adopted by Mr. J. B. GARDINER to warm the Synagogue of the Spanish and Portuguese Jews, in Bevis Marks; that object having been successfully attained by the admission of warm air from a chamber beneath the building.

Mr. D. MOCATTA read a paper descriptive of a distillery and its appurtenances recently erected from his designs in London; with some observations on the principles of distillation, heating furnaces, and general ventilation.

Mr. E. J. ANSON described a modification of the "Polmaise" system of warming, applied to a vinery near London. A discussion arose on the ill effects of the system if applied to general purposes, in consequence of the vitiated air being reheated.

Remarks were made on the consumption of smoke, and also on the necessity of providing means of ventilation wherever warm air is introduced.

RAFFAELLE.

The following is the *Brevc* of Pope Leo X., by which he conceded to Raffaelle the license to purchase all stone and marbles required for the construction of St. Peter's, and to prevent the destruction of ancient monuments and inscriptions by the masons and builders of Rome.*

"TO RAFFAELLE URBINATE.

"As it is most necessary for the construction of the Roman temple of the Prince of Apostles, that stone and marble, of which we ought to have an abundant supply, should be rather procured at home, than be conveyed from abroad; and as it has been ascertained, that the ruins of Rome contain a great quantity of these materials, and that all persons who, either in Rome or even in the neighbourhood, intend to build, do appropriate the same to their own use; I make you, whom I use as the master of this said temple, the overseer of all the marbles and stones which, henceforth, may come to light at Rome, or at a distance of ten thousand paces therefrom—for this reason, that you shall purchase for me those which may be proper for the edification of this temple. Therefore, I command all people, middle, highest, lowest, that wherever they shall, hereafter, dig out marbles or other stones, of any kind, within the space assigned by me, that they shall acquaint you, the overseer, forthwith, of the nature or kind of every thing so discovered or excavated. And also, that whoever shall not do so within three days from the time of such discovery, he be fined from 100 to 300 gold coins, as shall appear to you fit. And, moreover, as I have been informed, that much of ancient marble and stone, engraven with inscriptions and other monuments—which monuments often bear some exquisite stamp of art, and ought to be preserved for the cultivation of literature and the improvement of the Roman tongue—are vilely cut up by the marble-workers as building material, and that thus the inscriptions are destroyed, I command all persons who exercise the trade of cutting marble and other stones, that, without your orders or permission, they may not dare to cut or work any inscribed stone,—applying the same fine, as aforesaid, to all who may act otherwise than I command.—Given this sixt Cal. of September. Year three. Rome."

J. L——Y.

* Petri Bembi epistol. Leonis X., P. M. Lugdun. 1538. 8vo. p. 246.

REGISTER OF NEW PATENTS.

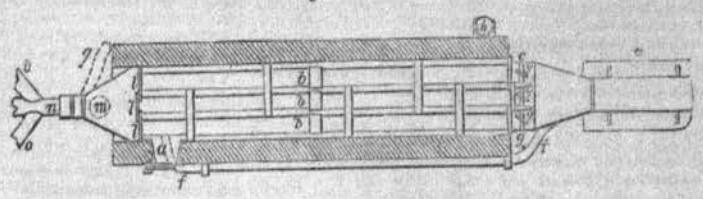
HEATING APARTMENTS AND BUILDINGS.

ANTHONY NATHAN DE ROTHSCHILD, of London, merchant, for "*Improvements in heating apartments and buildings.*"—Granted April 28; Enrolled October 28, 1846.

This invention relates to heating any desired space, by forcing heated air by mechanical means to the space to be heated; or to heat or dry various manufacturing articles in the same manner, and also to lead heated air for any desired purpose, whether perfectly dry or containing the moisture required for various purposes, to any situation that may be required, and is well adapted to warm churches, hospitals, theatres, saloons, bathing establishments, barracks, manufactories, prisons, horticultural establishments powder-mills, breweries, &c., &c., as well as for other purposes where a high and regular degree of heat is required.

The apparatus is shown in the annexed engravings. *a* is a fur-

Fig. 1. Plan.



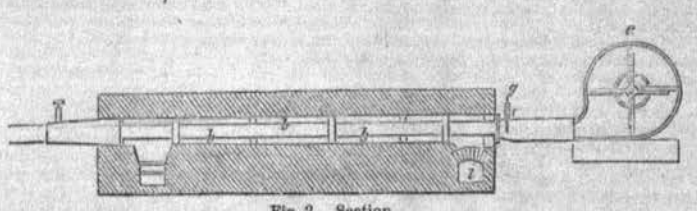


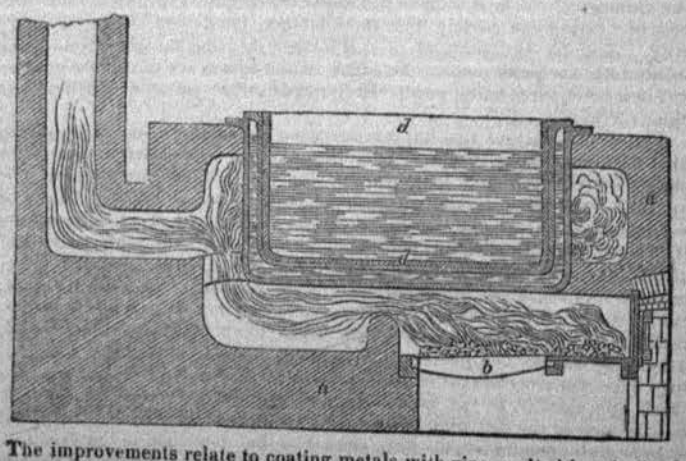
Fig. 2. Section.

nace, in which are placed cast-iron pipes *b b b*, the number of which may be increased if much heat be required; pipes of an oval form have been found most convenient. The pipes are heated by the fire *a*. The entrance of the pipes is connected at *c*, with a ventilator *e*, set in motion by mechanical force, which forces pure atmospheric air into the pipes *b*. The same ventilator forces also a strong current of air through the pipe *f*, to the fire. All the pipes have valves, *g g g*, to increase or decrease the current of air. By being driven through the heated pipes, beginning with the lowest and ending with the highest temperature, the air acquires a very intense heat. It has been found that the most convenient length of the cast-iron pipes, to produce high temperature, is 15 feet, which allows the smoke with the circuit (in *h*), and pressed down (in *i*), to leave the chimney with the temperature of the open air. To the end of the pipes *l*, united in one current of air by the chest *m*, is attached to the conduit pipe *n*, which, with its branch pipe *o*, conveys the heated air in any direction desired.

Should it be desired to convey warm or hot moist air, this object may be easily obtained, either by introducing steam, if the motive power is a steam-engine, into the conduit pipe in *q*, or by placing an iron vessel in the chest *l*, which vessel fills itself from the outside in the same ratio as the water in it decreases by evaporation.

APPARATUS FOR MELTING ZINC.

ANDREW SMITH, of Princes street, Middlesex, engineer, for "*Improvements in coating or covering metals for preventing oxidation.*"—Granted Feb. 11; Enrolled August 11, 1846.



The improvements relate to coating metals with zinc, melted in a bath of lead or tin, or any suitable medium that melts at a lower heat than zinc,

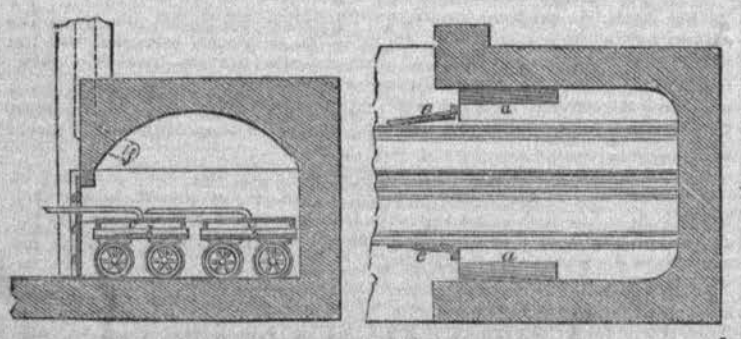
which is effected in the manner shown in the annexed engraving, representing a vertical section of the apparatus, which consists of a wrought or cast iron pan or vessel *d*, for holding the zinc, placed within another wrought or cast iron pan *c*, with a span of about 1½ inch all round and under the upper pan; this lower pan is set in brickwork *a*, over a furnace *b*, and surrounded by the flue, and contains molten lead, or lead combined with tin, through which the heat is transmitted to the upper pan, containing the zinc; the upper pan is lined on the inner face with fire-clay or fire-brick, to prevent any galvanic effect by the action of the zinc on the iron. By this method the zinc is kept in the bath at an even temperature of about 800° Fahrenheit.

IMPROVEMENTS IN GLASS.

James Timmins Chance, of Handsworth, Staffordshire, glass manufacturer, and Henry Badger, of West Bromwich, glass stainer, for "*Improvements in the manufacture of glass.*"—Granted April 28; Enrolled October 28, 1846.

The improvements relate, first, to the application of heat to sheets, panes, or plates, or other articles of glass, when they require to be reheated for any purpose, such as the producing stained, painted, enammelled, or other glass, which has been hitherto effected either by placing the glass upon metallic shelves within a muffle, and applying the fire externally, or by placing the glass in a kind of reverberatory kiln, upon a bed of stone or burned clay, and then applying the fire internally and directly upon the glass. By the former method there is a difficulty in preventing plates of glass from becoming bent or cockled, and in heating the glass uniformly; and, by the latter plan, the direct action of the fire upon the glass is injurious.

The improvements consist in so applying heat that the advantages of the two methods above mentioned are united, and, at the same time, their respective peculiar defects are avoided. In carrying out this part of the invention, the glass is laid upon a suitable bed (stone is preferred), and the glass covered by suitable covers, so as to enclose the glass in a chamber, by which the direct action of the fire on the glass is prevented, the inverted pans, for the time being, producing close chambers within the kiln. In the top of each cover there is a small aperture, communicating, by means of a pipe, with the outside of the front of the kiln, this contrivance being intended to allow of the escape of any vapour. In order to facilitate the practical operation of enclosing the glass in covers, moveable beds are preferred, placed upon an iron carriage running upon rails, the kiln being properly constructed for receiving such carriages. The annexed engravings show a plan and longitudinal section. *a a* are the fire-places; *b b* carriages, with a bed or beds; *c c* inverted pans or covers. The carriages are introduced into the kiln at the doors *e e*; the doors are then closed, and the flame and heat will be reverberated within the arch, and then pass off up the chimney *f*, which is to have a damper to regulate the draft. The process of heating and cooling the glass is then conducted in the ordinary way. And for the purpose of still further securing the glass from being injured by the fire or smoke, the edges of the covers are fitted into grooves cut into beds, there being powdered chalk, or other suitable substance, to close the joints.



The second part of the improvements relate to the mode of applying heat to sheets, panes, or plates of glass, when it is desired to alter their shape, whether to render them more flat, or to give them any required curvature. According to the methods generally adopted, the kiln has to be cooled considerably before a second charge of glass can be introduced into it. Now, the improvements consist of so employing moveable beds and covers, as described, that the cooling down of the kiln is rendered unnecessary, and the glass, when enclosed in the chambers formed on the beds, can be safely introduced into the flattening or bending kiln, without necessarily reducing the temperature of the kiln. The moveable beds aforesaid, previously to their being charged with glass, are to be heated to a temperature approximating to that of the kiln itself: this is done by means of a small kiln, similar to the main kiln. When the glass has remained sufficiently long in the flattening or bending kiln, it is withdrawn along a lear or long arch opening into the kiln, similar to that described in the specification of a patent granted to the said James Timmins Chance, July 7th, 1842. This lear or arch, however, is not an essential appendage to the present system of the patentees, because the beds and the covers above mentioned may be of such a thickness as to allow the glass to be withdrawn from the kiln without the intervention of a lear or long arch.

GLAZING CAST IRON.

Timothy Kenrick, of West Bromwich, Staffordshire, ironfounder, for "*Improvements in glazing and enamelling the surfaces of Cast Iron.*"—Granted May 26; Enrolled Nov. 26, 1846.

The improvements relate to coating and glazing articles of cast iron, with two separate coats, one to give it a body, and the other the glaze, in the following manner:—The cast iron articles are first to be thoroughly cleaned, and then to be coated with a composition, consisting of 100lb. of calcined flints and 75lb. of borax, both ground fine and fused; when cooled, 40lb. of this mixture is to be added to 5lb. of potters' clay, ground in water till of such a consistency, that when the article is dipped, it will retain a coating 1-16th inch thick. It is then allowed to set, and while moist, the glazed composition is carefully sifted over the surface, consisting of 100lb. of cornish stone, ground fine, 117lb. borax, ground fine, 35lb. soda ash, 35lb. saltpetre, 35lb. slaked lime, 13lb. white sand, and 50lb. white glass, well pounded; the whole are mixed, and well vitrified: when cool they are ground to a fine powder, washed, and dried; 45lb. of this mixture to be added to 11lb. of soda ash, in hot water, and well stirred, and then dried in a stove. When the article has received the glazing it is placed in a stove, and kept at a temperature of 213° Fahr. Afterwards it is fired in a kiln or muffle, raised to a heat sufficient to fuse the glaze; then removed and examined, and if the glazing be not perfect, the mixture is sifted over it, and it is again subjected to the action of the kiln or muffle.

For coating the interior of iron pipes, the first mixture, or body coating, is poured through the tube, at the same time turning it round so as to insure its contact with every part throughout its entire length, and whilst moist the glazing powder is passed through in the same way; after which the tube is to be treated as above described.

The patentee does not claim glazing the *interior surfaces of vessels of capacity*, but only for enamelling the external surface of such articles, and the enamelling and glazing of cast-iron Italian irons, box irons, knobs for door handles, and such like articles, and the inside of cast iron pipes, and ornamental surfaces of cast iron ornaments.

IMPROVEMENTS IN SMITHS' WATER TUE-IRONS.

By W. Noton.

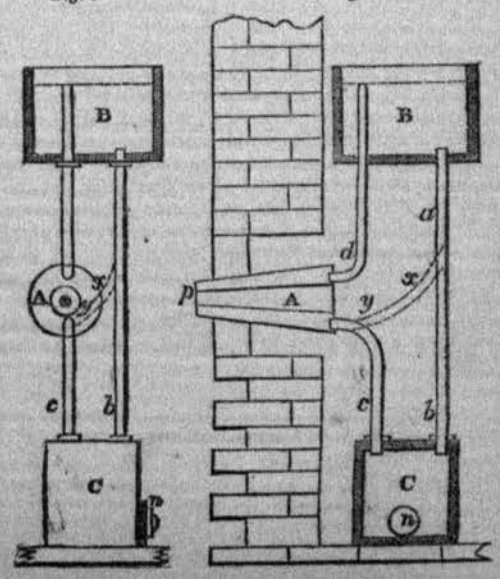
(Reported in the Franklin Journal.)

The smiths' water tue-iron as fitted up on the ordinary construction, is bad in principle, lasts a very short time before it is destroyed, and is eminently calculated for being an expensive item in the economy of the smith's workshop. Much inconvenience and hindrance results from the frequent stoppage occasioned by the failure of this useful appendage to the smithy fire.

My attention was directed to the circumstance, eight or nine years ago, with the intention of finding a remedy for, or at least an amelioration of the evil. Upon examination of the disabled tue-iron, I found the inside, more especially the end nearest the fire, generally filled up with a substance sufficiently solid to prevent any water getting to that part—the place where it is most required to carry away undue temperature; thus the tue-iron is not fairly worn, but burnt out before its time.

What is meant by the ordinary construction may be understood by reference to figs. 1 and 2, of the prefixed sketch:—

Fig. 1. Fig. 2.



A, water tue-iron. B, cistern for water, at a convenient height above A. *a x y*, wrought-iron pipe, connecting the lower part of the cistern, B, with the lower part of the tue-iron, A. *d*, another pipe, connected with the upper part of A, and passing either through the bottom of the cistern B, or by one side, and over the top with a bend. Water poured into B will descend by the pipe, *a x y*, into the tue-iron, A, driving the air before it up the pipe, *d*, and if sufficient water be supplied till it stands at the height shown by the line in the cistern, the whole of the pipes and tue-iron will be full of water.

In actual working, the nose, *p*, is covered with burning coal; the water soon attains a boiling temperature, and steam being formed, a portion of the water is driven out of the tue-iron up the pipe *d*, into the cistern B, when a fresh supply descends by *a x y*, to be in its turn heated and driven out as before.

If distilled water could always be supplied to the cistern B, and that kept clean, the tue-iron would have a fair chance of doing its duty to the end; but as it is not so, and as there is a great probability that other substances get into the cistern, and ultimately find a settlement in the tue-iron, some contrivance was desirable for preventing the accidental, or perhaps, in some instances, wilful choking of the tue-iron. The means adopted for this purpose will be readily understood by again referring to the two figures. Instead of the water descending by the curved pipe *a x y*, it is conveyed by the straight pipe *a b*, into the cast-iron box C, which is fixed considerably below the tue-iron, and must first be filled before any can rise up the pipe *c*, into the tue-iron. Should any sand or ashes get into the cistern B, it will settle in the box C, and not in the tue-iron, which will be supplied with water containing no heavy particles. A mud-hole door *n*, is provided, by which the box may be cleaned out at any time when the work is not going on. This additional apparatus, if attended to, will ensure a satisfactory working and add a considerable period to the existence of the water tue-iron. The box C, I have made, is of the capacity of one cubic foot to each fire, and I would recommend that the mud-hole door be opened every two or three weeks according to circumstances.

ST. PAUL'S CHURCH, ALNWICK.

SIR,—In your notice on new churches in the last number of the Journal, you have made some remarks on the seats in the chancel of St. Paul's Church, Alnwick, and on the Duke of Northumberland, which I am sure you would not have done had you written from actual observation and knowledge of the case. I therefore beg leave to lay before you the facts. You are correct in denying the name of stalls to the seats in the chancel; they are not stalls, neither are they pews—but *open seats*, two rows on each side, and the end of one row on the south side prepared so that the duke can wheel his chair into it. In the aisles of the chancel are seats fitted up and reserved for the boys of his grace's school.

The castle not being in the district of St. Paul's, the family, with few exceptions, never go there. And I may say (from having been well acquainted with the feelings under which the duke has acted throughout this munificent work), that the only privilege he desired, was to be able, when he did go to that church, to get to his place—seat I cannot call it—as quietly and unobtrusively as was possible, considering the affliction he labours under.

I am, Sir,
Your obedient servant,

21, Savile-row, Dec. 4, 1846. A. SALVIN.

*** The explanation given by Mr. Salvin is perfectly satisfactory as far as it refers to the Duke of Northumberland, and we readily believe that his munificence has been characterised by its usual unobtrusiveness, and that the architect has executed his task with his usual ability. But we cannot regret having insisted that a church is not the place for mundane distinctions, and ought not to contain privileged seats for privileged worshippers. The remark is intended to be perfectly general, and this protest against a specific application of it is an admission of its abstract correctness.

The question respecting the propriety of setting apart a large portion of the church for liturgical purposes has been learnedly discussed on both sides. It is not within our province to consider it except with reference to architecture; we certainly believe that the architecture of a church may be faultless where the distinction of nave and chancel is not maintained, and that the services may be conveniently performed in such a building in strictest conformity with the rubric. The Temple Church in London is an eminent instance. Where there are distinct chancels, it may also be objected that no one portion of the laity ought to be admitted in preference to the rest—the exception made in favour of singing men and choristers has no more valid excuse than the paid attendance and musical ability of this portion of the congregation. Besides, the rubric expressly directs that the whole "people," not a selected few, are to engage in this service.

Architects who view the question in this common-sense way incur a certain amount of vituperation, to which the slightest exercise of moral courage would render them perfectly indifferent. It is certainly to be regretted that the controversy has not been *authoritatively* settled. On one point connected with it there can, however, be no dispute. If, in a new church, a chancel be built at all, it ought to be set apart exclusively and strictly for its professed purpose. To build a chancel, and then suffer the laity to occupy it, or to erect stalls (as at St. Giles's, Camberwell,) which are merely superior seats to be had for paying,—is an idle, ostentatious retention of forms, after their significance and purpose have ceased.

BURNETTIZING TIMBER.

SIR,—In looking over your Journal for December, I meet in the "Notes of the Month" with an account on "Burnettizing Timber and Marine Worm," which statement I beg you to correct, it being replete with errors. I am the person by whom the experiments were made for Sir William Burnett; having given the subject of marine worm attention for many years past. Your correspondent is totally unacquainted with the subject he handles, and asserts the specimens were "duly immersed in his (Sir William's) solution;"—they were not immersed in the solution known to the public as Sir William Burnett's far-famed solution. When the pieces of wood (about six in number) arrived from him, I received them understanding them to be pieces immersed in order to try the effect of a preparation—which preparation is very different to the former, which stains the wood considerably; but in this instance the wood was not in the least discoloured. The far-famed I am perfectly acquainted with, seeing the use of it every day.

Sheerness, Naval Yard, JAMES MITCHELL,
Dec. 12, 1846. *Civil Engineer.*

*** The paragraph was taken from the Naval Intelligence in the daily papers. With all due deference to Mr. Mitchell, we should have been much better pleased if he had stated what preparation had been used by Sir W. Burnett for *the* six pieces of wood, which it is not denied had failed, and we should be glad if Mr. Mitchell would state whether Burnettized timber, or any other prepared timber, had generally withstood the ravages of the marine worm at Sheerness.

SETTING OUT RAILWAY CURVES.

SIR,—I have seen, in your Journal for December, Mr. Tait's notice of my letter to you, inserted in your October number, and I have read his description of an instrument invented by him for setting out railway curves.

The objection which appears to his instrument seems to be obvious: it clearly is that the principle is liable to much perplexity and error, because it is founded on a system of what surveyors call "building"—that is, making the accuracy of the whole work depend upon the nicest accuracy of a great number of minute parts, consisting of arithmetical calculations in trigonometry, accurate measurement of small distances, exactness of instruments, straightness and uprightness of boxing rods, &c. &c. This machinery appears to me to be too complex for practice.

It is objected by Mr. Tait to my proposal, that it may be possible a surveyor may not be able to *see* the two extreme points of a curve. In answer to this, I need only say that surveyors, employed to set out curves, would always be in possession of means to find out, without any great trouble, and without trigonometrical calculations by means of arithmetic—but merely by the aid of a common theodolite—the *direction* of the chord line: having once determined this, he must be a poor surveyor who does not see his way clear in laying down a curve, the radius of which is given. The method follows from the system of chords mentioned in my former letter, and is obvious to any tyro in geometry.

The system suggested by me deduces particulars from generals; in other words, it proceeds upon the plan of ascertaining fundamental or general points, and producing the minor points by means of them. The plan of Mr. Tait proceeds by "building" a great number of minute triangles, one upon another; which is not, amongst surveyors, accounted orthodox.

Your's,
Oswestry, Dec. 5, 1846. AN ENGINEER OUT OF EMPLOYMENT.

ENGINEERING LITERATURE.

SIR—In your reply to Correspondents in the December number, I noticed your answer to a six years subscriber, respecting the best published account of the details of the Steam Engine; and, notwithstanding you referred him to the treatise of the Artizan Club, yet your opinion was, "that a satisfactory work on the Steam Engine remains among the desiderata of Engineering Literature." I am so much gratified that you have given expression and publicity to an idea which I believe very many persons have long thought most desirable, that I cannot forbear asking if it would not be possible to form a society for the purpose of publishing some valuable works on the "Steam Engine and Engineering

in General," on the same plan as the Camden and Shakespeare Societies have already done so successfully, and which, it appear is to be followed by another, to be called the Hackluyt Society.

For myself, I shall be happy to contribute towards any subscription which may be made to carry out such a measure; and I have no doubt I could, among my friends, obtain several names and subscriptions, in addition to my own.

I am, Sir, your obedient servant,

A READER OF YOUR JOURNAL FROM THE COMMENCEMENT.

Lewes, Dec. 24, 1846.

P.S.—If my suggestion is considered practicable, I will communicate with you again. I have the first volume of "Farey on the Steam Engine:" can you inform me if the second volume is likely soon to be published?

*** We may probably reply to this letter hereafter.

NOTES ON FOREIGN WORKS.

Transactions of the Archæological Institute of Rome.—The volume o the proceedings of this Society, just published, again proves the richness of antiquarian relics, and likewise an increased activity of the Society, under the auspices of the present Pope. The first memoir contains Professor Ulrich's travels in Greece, from Athens to Chalkis, Anthedon, Aulis, and Oropos—places scarcely yet explored by any antiquarian. Amongst the monuments discovered is a bronze tablet, with a marsian inscription, found at Rapino, and, most probably, the only relic of the kind extant. Another tablet of lead, with a Grecian imprecation, is interesting to the searchers of linguistic and religious antiquity.—The celebrated architect, L. Canina, has contributed a paper on a round pedestal in the Lateran, with emblems of Vulcan upon it.—The most attractive paper, however, is that of M. Welker, on the portrait of Sophocles. M. W. has compared the splendid statue in the Lateran, found at Terracina, where the poet is represented in a proud, nay triumphing attitude—with that of the Mosaic pavement lately found at Köln.—Two double entaglios of Sophocles and Euripides, from the collection of M. Torlonia at Rome, were exhibited. The configuration of the two heads is very characteristic,—Sophocles handsomer, quieter, of great regularity and harmony of form of head, approaching the ideal ascribed by the ancients to Jupiter; while that of Euripides is more shrewd, active, and bustling.

The great picture of Garofolo, at Rome, representing the descent from the cross, a huge canvas, comprising seven figures of life-size, has been hitherto in a very precarious condition, on account of the wood, on which it was stretched, having become rotten, if not decomposed. M. Radice, its present owner, knowing the great artistic value ot this historical picture, engaged the famous restorer, M. Bunosi, to transfer the canvas to another substratum. This has been done so successfully, that M. Overbeck has expressed his perfect coincidence and approbation.

Railway from Naples to the Roman Frontier.—The Neapolitan government have granted to M. Falcou de Cimier the concession to construct a railway from either Capua, Ceprano, or Fondi, direct to the Roman frontiers; but under this condition—that the newly discovered system of Jouffroy be tried on the line. This system, which is said to afford greater security to travellers, and a saving of expense, will first be tried on a space of two miles; a commission is then to decide whether it be advisable to employ it on the entire line.

Railways and Coal Mines in Bohemia.—Austria boasts of having constructed the first railway on the continent of Europe, namely, the Budweis and Linz line, commenced in 1825, although merely worked by horse power. Another from Prague to the coal mines of Lahna, a length of 30,240 cubits, was begun in 1826. It was at first intended that this line should extend to Pilsen, and thus form a junction with the Bavarian States' lines. The Lahna coal mines now supply fifteen manufactories with 15,000 tons of coal monthly; but as this coal yields a superior kind of coke, which could be advantageously used on the Great North Line (whose engines have hitherto burnt wood), these new branch lines will be of great commercial value to the whole country.

The Erection of the Terminus of the Paris and Lyons Railway, at the former city, excites much controversy among our French contemporaries. The right bank of the Seine was originally fixed upon, but the subsequent underhand doings of certain land proprietors, who desired it near the Boulevard Mazas, seems to have balanced the decision in their favour. Now, the Place de la Bastille seems likely to suit all requirements. The interests of the whole line, and the immense capital which has to flow through it, demands that the terminus should be as near as possible to the centre of the commercial and banking activity of Paris.

The New Opera House at Vienna.—The present building near the Kärtnerthor, is one of those insignificant edifices erected under the late Emperor. This having become too palpable, the plan for a new one has been devised. The two gates of Carinthia will be pulled down, and replaced by one in a monumental style; the ramparts on this side of the city demolished, and the limits of the city extended; by which alterations, sufficient space for a splendid new Opera House will be gained. As the lease of the present theatre, however, does not expire for two years, the operations will not commence until that time.

Irrigation of Algeria.—The French Minister of woods and public works has nominated a commission, chosen from among the general staff of surveyors of roads and bridges, to examine the plans and projects sent to Paris from Africa, for the barrage of the rivers of Africa. These plans have been made on the spot, by another commission, which is surveying Algeria for that purpose. The first plans of irrigation will be executed on the waters of the plain of Mitidja.

The Guildhall, Louvain, Belgium.—By a curious accident, the name of the builder (hitherto unknown) of this splendid structure has been discovered, by one of the keepers of the archives at the Guildhall. His name was Matheeus de Layens, master mason of the city of Louvain. While occupied on this task, for thirty years, he received four sols (half-pence) per day in summer, and three sols in winter; and when this immortal work was completed, the municipality gave him a *recompense* of five Peters and ten sols!

City Embellishments in Austria.—The imperial building court councillor, M. Springer, has undertaken the rebuilding of the façade of the Altstadt guildhall, at Prague, which will be adorned by six bronze statues of Bohemian monarchs, sculptured by M. Marx. The corporation have voted a sum of 80,000 florins (equivalent to £20,000 English) for that purpose.

Restoration of the Ulm Minster.—Amongst the most important monuments which the grandeous art-taste and generous piety of a great age has left to its not always grateful successors, the Ulm Minster occupies a considerable place. It covers an area of 58,000 square feet, and is not surpassed by any mediæval cathedral, Cöln and Speyer excepted. Its naves, complete as they are, are of gigantic proportions, the principal one being 141 feet in height, and the four lateral ones 70½ feet; the choir 90 feet. The spire, had it been completed according to the plans of the original architect, Mathew Boblinger, would have overlooked even that of Cöln, as it was planned at a height of 475 feet (Rhenish), while the latter was to be 474 feet. The spires of Freyburg, St. Stephen at Vienna, and even Strasburg, are all of a lesser height. Thus, what is related by tradition may well be true—namely, that the Ulm burghers, at whose expense this edifice was raised, said then, that they wanted to erect a *case* for the Strasburg Minster. This gigantic building was begun in 1377, the names of the architects being Heinrich and Michel (most probably only their Christian names). When Mathias Boblinger took charge of it, from 1480 to about 1490, the building had proceeded as far as the platform. A subsidence of this stupendous mass was subsequently apprehended, and Boblinger was compelled to fly from Ulm; Bunkhard and Engelberger de Hornberg being then appointed architects. They underran the spire with such tremendous walls, that professional men say *any height* can be raised thereon. The building was not subsequently proceeded with, if we except those graceful columns erected by Lienhart Aeltlin (1502-1507), by which the lateral naves are divided. Want of funds—and still more, the approach of the Reformation, prevented every further endeavour to complete it. Thus it remained until 1844, when the tendency to restore the mediæval monuments of Germany—already manifested in that of the dome of Cöln—reached also the inhabitants of Ulm. The completion of the spire is certainly, up to the present time, a subject of mere wish and desire; but that of the central nave (only inferior to that of Cöln by 20 feet) is more easily to be achieved. The projected lateral pillars, which support the central nave and the still unfinished turrets, are yet wanting. The completion of the two easterly turrets would at once impart to the whole a more perfect appearance. If all this be done—as it has already been begun—then the huge spire could be attempted, the expense of which, albeit large, would be only one-third of the cost of the completion of the dome of Cöln, calculated at five millions of dollars (at four shillings). The works are under the sole direction of the city architect, M. Thrän, whose energy is generally praised and appreciated.

Great New's Hall at Berlin.—M. G. Julius has just completed the erection of the above establishment, in which the periodicals of all nations and countries, and of every branch of human knowledge and on every subject, are to be met with. Situated in the very centre of the town, its success is almost sure. [A similar place does *not* exist in London.]

Raffaelle an Architectural Author.—If some persons are astonished to hear that Raffaelle, whom they supposed hitherto the painter of Cartoons and Madonnas, was also the completor of St. Peter's dome, at Rome, they will be still more surprised to understand that he was also an author, and this on a professional subject. His "Report to Leo X. on the preservation of the antiquities of Rome," is a jewel of delicate yet deep thought; but it is the only thing which the divine painter ever put to paper, his mind manifesting itself in a different sphere.

The Boldest Enterprise of the Age is, certainly, the draining of the Zuider-Zee in Holland, the expense of which is calculated at 61 millions of florins (10 millions sterling). The plan is ready, and embraces a gigantic dyke to protect the new land against the force of the Baltic Sea—a maritime canal, accessible at all times of the tide, to connect the sea with Amsterdam. No plan, except to form a railway over one of the passes of the St. Gothard, can be compared with the above.

Acoustics of Theatres and other Public Auditory Buildings.—It has been tried in some of the recent constructions of theatres in France, to provide spaces in the body of the walls and pilasters, for increasing the acoustic character of the building. The rationale of this scheme is quite correct—it agrees with the theory of sound, lately brought before the French Insti-

tute, that it is *not* a vibration of air, but a substance—a material body, like electricity, magnetism, heat, &c. It is obvious that walls, and other solid work, cannot and will not propagate the *rays* of sound dynamically, as well and accurately as air does, which is its appropriate menstruum and vehicle. Of what shape these spaces are to be, and where they are to be placed—both according to the shape and size of the building—is a subject open to the investigation of architects. It is curious, indeed, to know that Aristotle says (Problem II. sec. 11) that the ancients placed empty vases or pots in the walls of theatres, forums, &c., for increasing the vibration and power of sound.

Fall of a Building on the French Northern Line.—On Friday, the 20th Nov., the large wooden building at Lille, in which the company gave the grand banquet to the French princes and the company invited to the inauguration of the line, and which was recently being prepared for a waiting-room for passengers, fell with a frightful crash. Not one of the supporting timbers resisted. The excavation of the earth around the supports was the cause of the accident.

Belgium.—The Luxembourg company contemplate building eight streets in the London style next spring around the station to be erected in the Quartier Leopold, Brussels, for the occupation of opulent English families It is well known that the English establishing their residences at Brussels have always chosen the upper part of the city for the benefit of the air o the park and neighbourhoood.

Tunnelling the Alps.—The *Moniteur Belge* announces that experiments have been made in order to test the efficacy of a machine just invented for the purpose of effecting a new and speedy method of boring tunnels. It is proposed to apply this machine to the construction of the great tunnel about to be commenced in connection with one of the Italian lines. The machine was placed in front of the web, and effected a bore to the depth of 18½ centimeteres (7 inches) in thirty-five minutes. At this rate, the new invention will complete upwards of 5 metres (16ft. 6in.) of bore per day, and the proposed tunnel through Mount Cenis will be finished in the space of three years. The experiments have been repeated twice before several of the first engineers of France, and with the most complete success.

NOTES OF THE MONTH.

Electrical Telegraph.—At the Paris Academy of Sciences, M. Brégue exhibited a new electro-magnetic battery, intended for the line of electrica telegraph of the Paris and St. Germain railroad. A prepared magnet of steel is fixed perpendicularly upon a strong board. Above and very near the poles a rectangular plate of soft iron is fixed upon an axis, which bears a pinion commanced by a large copper wheel. Upon the plane are engraved the letters of the alphabet, and opposite each letter there is a hole. The axis of the wheel has a handle, to which is fixed a steel point, capable of entering the holes of the wheel. The handle has a hinge, in order that it may be raised or lowered, and is free at the centre of the wheel, so that when the point is out of a hole the handle may turn in either sense to find the letter and transmit it. Very near the edge of the wheel is a lever, the small arm of which is above its centre of motion, with a larger one under, which serves to work a second lever; they are combined in such a way that a slight motion of the small arm of the first may describe an arch to the extremity of the large arm of the second. The upper arm of the first lever serves as the point of arrest of the handle, at the same time that the large arm of the other stops the movement of rotation. The apparatus is so contrived as to engage and disengage itself in the finding and transmission of the letters, without any effort on the part of the person working the battery.

Steamers for the Ganges.—On the 21st Nov. a number of scientific gentlemen connected with India and steam navigation, met at the iron steam ship works of Messrs. H., O., and A. Robinson, Mill Wall, Poplar, to inspect a large iron steamer, intended for the navigation of the river Ganges, between Mirzapore and Calcutta, and named (by the spirited Company who ordered her) the "Mirzapore." She is the third of a line of steamers for the Ganges designed and constructed by the same firm, and is the largest river steamer ever built, with one or two exceptions in America, her length being 250 feet and her breadth inside the paddles 38 feet. The vessel is an admirable combination of strength and lightness, and embraces some novelties in iron ship-building to attain this desideratum in the navigation of shallow rapid rivers. The engines are of the collective power of 250 horses; are horizontal and perfectly unconnected; their valves are on the equilibrium principle; are acted upon by cambs, and are well geared for the easy manipulation of the engines. The first of these steamers, named the "Patna," has proved to be admirably adapted to the navigation and traffic of the Ganges, and the company have in consequence given orders for the immediate preparation of additional steamers.

Restoration of Llandaff Cathedral.—The Dean has just issued a statement of the progress of this work. The eastern chapel has been completely restored; the windows and open parapet work at the east end of the south aisle are in progress. Active operations have been commenced in the choir, and a noble arch of Bishop Urban's work, with elaborate mouldings, has been opened. Beneath this a beautiful screen of Bishop Marshall's, A.D. 1018, has been exposed; as also a beautiful recessed monument in he south-east wall of the choir.

All Saints, St. John's-Wood.—Two stained glass windows have been presented by Mr. Fairs.

Holyhead Harbour.—The Admiralty have given notice of their intention to deepen and dredge this harbour, and to construct retaining walls and wooden jetties.

South Staffordshire Mines.—A weekly paper says—"We have been informed, on the best authority, that the Government have appointed an experienced engineer, thoroughly versed in the system of mining, who will immediately proceed to visit the iron and coal mines in South Staffordshire."

Cleopatra's Needle has, it is stated, been offered by the Bey of Tunis to Louis Philippe and accepted, and is to be placed in the Carousel at Paris.

New Act on Steam Navigation.—On the 1st January an important Act "For the regulation of Steam Navigation, and for requiring sea-going vessels to carry boats," comes into operation. Every vessel of upwards of 100 tons is to be provided with hose for extinguishing fire. Every steam-vessel passing another steam-vessel is to pass as far as may be safe on the port-side. No compensation is to be recovered for injury by vessels not exhibiting lights at night. In rivers steam-vessels are to pass as near as practicable to that side of the mid-channel which lies on the vessel's starboard. Owners are to transmit to the Board of Trade twice a year certificates of the efficiency of the engines, and are to report the supposed loss of any vessel, &c.

At Latheney Abbey, Gloucestershire, five ancient Norman pillars have been dug up.

Long Acre Improvements.—All the houses belonging to the Mercer's Company, in Long Acre, opposite the end of Bow-street, have been demolished, and a direct communication is thus established with Waterloo bridge. The new street at the end of St. Martin's-lane is rapidly progressing; it is one of the widest thoroughfares in London, its breadth being 110 feet.

The Fortifications at Sheerness.—Dec. 21.—These works continue to progress rapidly. The large and formidable battery opposite the dockyard gate, facing seaward, is now complete, with the exception of the curtain or parapet wall, which will shortly be proceeded with, after which the beds for the traversing platforms of from 40 to 50 guns will be laid down. The musketry walls connecting this battery, on the one hand to the fortifications at Garrison Point, and on the other to the land defences, are also complete, and present a fine appearance, being excellent specimens of substantial workmanship. These land defences, which extend continuously from the Thames to the Medway, interrupted only by the drawbridge to Mile Town, are now in course of being repaired and heightened, by the mud procured in the deepening of the moat which protects them. The excavations for the moat which surrounds the new battery, and which have been continued northward, as far as the second angle of the old works at Garrison Point, and southward into the moat surrounding the land defences, are nearly completed, and workmen are now engaged in several parts banking it up with rubble stone. The greatest number of men are, however, engaged in the construction of a ravelin, capable of containing 3,000 men, on the Mile Town side of the drawbridge. The moat is to be conducted round the ravelin, and a second drawbridge thrown over it. The repairs and alterations of the old works at Garrison Point are completed. The magazines are in course of being filled. New barracks, capable of containing 1,000 men, are to be immediately erected, and three Martello towers on the Isle of Grain shore, should the foundation prove satisfactory. A party of Sappers and Miners are at present engaged there making the necessary borings and examinations.

Analysis of a Peruvian Alloy, by Mr. Henry How.—This was a small plate of a yellow metal, which was taken from a band of similar plates surrounding a human shull: it consisted of—

Gold	38·93
Silver	54 82
Copper	5·80
	99·55

It is a question whether the metal is an artificial alloy or the crude product of a metallurgic process. The author was inclined to the latter opinion.—*Chemical Society.*

King's Well, Bath. Analysis of the Water, by Messrs. MERCK and GALLOWAY.—The whole method of analysis pursued in this investigation is given in detail in a paper to the Chemical Society, and the authors sum up with the following results in the imperial gallon:

Carbonate of lime	8·820
Carbonate of magnesia	0·329
Carbonate of iron	1·064
Sulphate of lime	80·052
Sulphate of potash	4·641
Sulphate of soda	19·229
Chloride of sodium	12 642
Chloride of magnesium	14 581
Silica	2·982
With traces of iodine and oxide of manganese	
	144·340

Its specific gravity is 1·0025 d its temperature 115°, the atmospheric being 68° at the time.

The Largest Merchant Vessel in the Worta.—This magnificent ship arrived in the Mersey last month on her first trip across the Atlantic. She is intended to take her station as one of the packet-ships between that port and New York. She is 188 feet long between perpendiculars, 195 feet from the stem to the taffrail, 42 feet extreme breadth of beam, 28 feet deep, and is 1,818 15-95ths tons, carpenter's measurement, or 1,511 31-95ths, Government measurement. It is estimated that she will stow 5,000 bales of cotton, or 3,000 tons of measurement goods. She has three decks, the same as a frigate, the upper one being as substantial, in proportion, as either of the others.—*Liverpool Mercury.*

Dublin.—The success of the School of Engineering, established by the University in 1842, has exceeded the expectations of its founders. Seventy students at present are attending its classes. The course of instruction lasts for three years. At the end of each year the students pass an examination previous to their being admitted into a higher class, and a final examination for the University diploma; the whole is under the control of Sir John Macneill, L.L.D., Professor of Engineering in the University.

Drainage of the Zuyderzee.—The works in operation for draining the Lake of Haarlem, seemed to have stimulated the ingenuity of the projectors of a still more gigantic undertaking—the drainage of the Zuyderzee, which according to a plan published at the Hague, is proposed to be effected by the construction of an immense dike, cutting off the communication with the North Sea, and by forming a canal between Amsterdam and the coast, into which are to be diverted the rivers which at present empty themselves into the Zuyderzee.

Demolition of Trinity Church, Edinburgh.—The North British Railway Company have projected the destruction of this ancient building, erected in 1462 by Mary of Gueldres, wife of James II. of Scotland, and containing her tomb. The conduct of the Commissioners of Woods and Forests in appealing to the magistrates for the preservation of this edifice, affords an admirable contrast to the cold, money-loving spirit which instigated its demolition.

A Gallery of Art at Calcutta has been projected. The Government offer to contribute 5000 rupees (£500).

Button, the Archæologist.—An entertainment in honour of this veteran supporter of the cause of English architecture was recently given at the Freemasons' Tavern. We regret to say that he himself was prevented by indisposition from attending.

Buckingham Palace.—The demolition of the colonnade in front of the south wing has been commenced.

Trinity Church, Paddington.—The foundations of this church have partially failed: the cause is stated to be as follows: The roads round the site of the church had been raised 16 feet above the natural level, the building was therefore supported on brickwork 16 ft. 6 in. high, that its base might be on the ground line. The embankments of the surrounding roads having sloping sides, and the foundation of the church having vertical sides, there was of course an intervening space to be filled in: the earth used for this purpose has pressed against the brickwork and caused it to yield.

Submarine Telegraph.—The South Eastern Railway Company have exhibited their confidence in this invention by making preparations to lay down an electric telegraph from Folkstone to Boulogne.

New Docks at Wisbeach, covering 13 acres, are about to be erected by the Eastern Counties and Great Northern Railway Companies conjointly.

Maddington Church has been restored. The stone work has undergone extensive reparation, and a new pulpit of stone has been erected.

St. Germain L'Auxerrois.—At this church, one of the most interesting Paris, a chapel painted by M. Amaury Duval, has just been exposed to view, and four others by different artists at Notre Dame, de Lorrette, and St. Sulpice, will soon be completed.

Holy Trinity Church, Liverpool, is nearly completed. The style is the Decorated, and the material red freestone. The church has a spire and transepts. The benches are fitted up with Honduras mahogany, and polychrome decorations are used as borders to the windows. Mr. John May, of Liverpool, is the architect.

DREDGE'S SUSPENSION BRIDGES IN INDIA.

For the following particulars of another failure of these bridges in India, taken from the *Calcutta Star*, October 5th, 1846, we are indebted to the attention of a correspondent in Calcutta, who states that the bridge at Jingurutchy was erected by military engineers, but that the iron work was sent to order from England.

"It is with deep regret we announce a melancholy and most fatal accident which has happened at Jingurutchy, nine miles this side of Jessore. The bridge there, recently completed by Captain Duncan, of the Engineers, has fallen. The chains gave way when the bridge was crowded with people, and at the moment three boats were passing under it, which were sunk with all their crews. Our informant says the loss of life had not been ascertained when a messenger was sent off to Captain D. with the report of the disaster; but he computes it at 100. We earnestly hope this may prove over the mark. We believe it was only the other day the bridge was examined by Major Sage and two other engineers, and favourably reported on."

The following paragraph appeared in a second edition of the same paper:—

"We have since learnt from Captain Goodwin, of the Engineers, that this bridge was constructed in England by Mr. Dredge, the patentee, and that Captain Goodwin reported unfavourably upon it on its arrival here; and also the committee, who examined it after its erection, decided that the structure was only fit to endure the weight which would be placed on it by ordinary traffic. On the occasion of the sad accident in question, some five or six hundred persons were on the bridge for the purpose of witnessing a poojah, and the accident was mainly owing to a sudden rush of the whole crowd to one side of the bridge, which our readers may remember was the case in the Yarmouth catastrophe, which happened about a twelvemonth ago. There is no doubt but that on such an occasion there should have been police stationed to prevent the structure from being overloaded."

THE GREAT BRITAIN STEAM SHIP.

Mr. Brunel has addressed to the proprietors of this vessel a report, dated December 14th, of which the following is a brief analysis:—

The ship is at present comparatively little injured. The strains and damage sustained are entirely local, and not communicated to the whole hull, as would have been the case in a wooden vessel, under similar circumstances. All the injuries done to the Great Britain might be repaired if she could be got into dock.

To this object all attention ought to be turned, as the ship would scarce pay the expense of breaking up; and if she were brought into port exactly in her present condition, she would be worth from £40,000 to £60,000. It would require, at least, three months to complete the means of floating her, and in the interim it is necessary that she should be protected against the effects of the sea. To this end, Mr. Brunel proposes to erect—not a fixed breakwater, which has been already proved impracticable—but a mass of fagots, used as in the protection of sea-banks in Holland. The strongest conviction of the cheapness and efficacy of this plan is expressed, though "few persons who have not seen the effect of a sea beating against fagots will share in it." The fagots are to be packed closely against the ship's exposed side for a considerable thickness and up to the level of the deck. The whole is to be bound into a compact mass by rods, driven through the fagots vertically, and is to be attached tightly to the ship by iron chains. About 10,000 fagots would be required.

So much for the means of protecting the vessel—next, as to the mode of subsequently raising her. Mr. Brunel is of opinion that this cannot be well effected by flotation. There are only 10 feet of water at ordinary high tide, and she has worked herself 5 or 6 feet into the rock and sand. The weight to be raised is 2000 tons, and therefore if the buoyancy of floating camels were resorted to, the apparatus would have to be of enormous magnitude.

It is recommended that, instead of hydrostatic, mechanical power should be employed, and that when the ship is raised sufficiently to allow the repairing of her bottom, she should be rendered water-tight, and then be towed to Liverpool or Bristol.

MENAI TUBULAR BRIDGE.

EXPERIMENTS AT BLACKWALL.

We have on one or two recent occasions witnessed experiments made on the huge model of the proposed tubular bridges of the Chester and Holyhead Railway, under the able direction of Messrs. Hodgkinson and Fairbairn, when several other eminent engineers were present. The principal object of the present experiments has been to ascertain the proper proportions of the sectional areas of the top and bottom of the tube. Great additional strength has been obtained by stiffening the side plates with vertical ribs of T iron, attached at equal intervals throughout the whole length of the tube.

In the first experiments, the sectional area of the bottom plate being 22½ square inches, of the top 24 square inches, and the sides 10 inches, a weight

of 58 tons produced a deflection of 3·2 inches. This weight was allowed to remain till the following morning, and the increase of deflection was found to be inconsiderable. The tube being subsequently laid on its side, in order to test its lateral strength, it was found that 9 tons produced 2 inches deflection, and 12 tons, the last load laid on the tube in that position, produced 3⅞ inches total deflection, including that due to the weight of the beam itself.

In the concluding experiments, Dec. 23, it was determined to load the model bridge till it was broken. The following table exhibits the deflection corresponding to each load:—

Experiments.	Load.	Deflection.
No. 1	31,612 lb.	0·70 inches
2	57,947	1·31
3	83,310	1·91
4	105,362	2·38
5	117,826	2·77
6	125,927	2·96
7	135,255	3·17
8	Same weight after remaining 9 days	3·22
9	139,567	3·38
10	144,352	3·48
11	149,684	3·70
12	151,772	3·81

With the last load, equal to 67¾ tons, the beam broke.

In order to a right apprehension of the manner in which the fracture took place, it must be understood that the thickness of the bottom plate had been greatly increased near the middle point of the model by additional plates, which were continued for 20 feet on each side the centre; and it was where the thin part, or single thickness of the bottom plate, commenced that fracture took place. The bottom plate was torn asunder with a very irregular line of fracture, not contiguous to the rivets. The vertical or side plates also gave way, but in them the rivets (24 on each side, of $\frac{5}{16}$ iron) were actually cut or sheared asunder, the rivet-holes being perfectly uninjured. The top or cellular plate remained perfect.

These experiments have suggested several improvements of details in the bridges to be constructed over the Menai and Conway: but at present the modifications are not defined sufficiently to be laid before the public. The utmost precautions have been taken to secure the strength and stability of the proposed structures. The greatest credit is due to the skill and perseverance displayed by Messrs. Fairbairn and Hodgkinson, and other gentlemen called in by Mr. Stephenson to carry on the investigation, and also to the liberality with which expensive models have been provided.

LIST OF NEW PATENTS.

GRANTED IN ENGLAND FROM NOVEMBER 25, 1846, TO DECEMBER 21, 1846.

Six Months allowed for Enrolment, unless otherwise expressed.

Henry Robert Ramsbotha m, of Bradford, York, worsted-spinner, for "Improvements in combing wool."—Sealed Nov. 25.

James Bullough, of Blackburn, Lancaster, and Adam Bullough, of the same place, for "certain Improvements in looms for weaving."—Dec. 1.

Henry Bridges, of Croydon, Surrey, coach-builder, for "certain Improvements in railway-wheels."—Dec. 1.

William Thomas, of Cheapside, city, merchant, for "Improvements in machinery for sewing or stitching various fabrics."—Dec. 1.

William Johnson, of Grosvenor Wharf, Millbank, gentleman, for "certain Improvements in machinery for raising or lifting and lowering weights or ponderous bo dies."—Dec. 1.

George Ellins, of Droitwich, Worcester, salt-manufacturer, for "certain Improvements in apparatus for manufacturing salt."—Dec. 1.

Richard Love, of Coleman-street, City, merchant, for "certain Improvements in paving streets, roads, yards, and other surfaces, over which carriages and beasts of burden have to pass."—Dec. 1.

Jacques Francois Pluel, of Lyons, France, chemist, for "Improvements in grinding wheat and other grain."—Dec. 1.

Samuel Cunliffe Lister, of Manningham, near Bradford, manufacturer, for "Improvements in combing wool."—Dec. 1.

William Mayo, of Silver-street, City, manufacturer, for "Improvements in the manufacture of aerated liquids, and in apparatus used for such manufactures, and when pumping the liquids, and also in bottling fluids."—Dec. 1.

George Fergusson Wilson, of Belmont, Vauxhall, Surrey, gentleman, and John Jackson, of Southville, Wandsworth-road, for "Improvements in the process of and apparatus for treating fatty and oily matters, and manufacturing candles and night-lights."—Dec. 1.

William Johnson, of Grosvenor Wharf, Millbank, Westminster, gentleman, for "certain Improvements in propelling carriages on railways."—Dec. 2.

Joseph Bancroft Reade, of Stone Vicarage, Aylesbury, Buckingham, clerk, for "certain Improvements in inks, and in the process by which the same are manfactured, and the application of some of these processes to the production of certain salts."—Dec. 3.

Thomas Craddock, of Birmingham, engineer, for "Improvements in steam engines and boilers, and in machinery connected therewith."—Dec. 3.

William H. Fox Talbot, of Lacock Abbey, Wilts, Esq., for "Improvements in obtaining and applying motive power."—Dec. 3.

Edmund Morewood, of Thornbridge, Derby, merchant, and George Rogers, of Stearndale, Derby, merchant, for "Improvements in the manufacture of iron into sheets, plates, and other forms in coating iron, and in preparing iron for coating and other purposes."—Dec. 7.

Eugene Bazlie, of Rouen, France, manufacturer, for "Improvements in obtaining heat during the manufacture of coke, and applying such heat to various purposes." (A communication.)—Dec. 7.

John Dacle, of Foxley, Kennington, Surrey, gentleman, for "an improved apparatus to be attached to boots and shoes, for the purpose of protecting the wearer from splashes of mud in walking."—Dec. 7.

Samuel Clift, of West Bromwich, Stafford, gentleman, for "certain Improvements in the distillation of tar and pitch."—Dec. 8.

Alexander Bain, of Hanover-street, Edinburgh, electrical engineer, for "certain Improvements in transmitting and receiving electrical telegraph communications, and in apparatus connected therewith."—Dec. 12.

Moses Poole, of the Patent Bill Office, London, gentleman, for "Improvements in the construction and working of electric telegraphs, and in apparatus connected therewith, partly applicable to other purposes." (A communication.)—Dec. 14.

James Yates, of Masborough, in the parish of Rotherham, York, engineer, for "Improvements in the construction of blast furnaces."—Dec. 14.

John Keeley, junior, of Nottingham, dyer, for "Improvements in dressing or finishing lace, and other fabrics."—Dec. 14.

William Longmaid, of St. Helen's, Lancaster, gentleman, for "Improvements in the manufacture of alkali and chlorine."—Dec. 14.

Elijah Galloway, of Buckingham-street, Strand, Middlesex, civil engineer, for "Improvements in rotatory engines, and in locomotive carriages and railways."—Dec. 14.

John Shaw, of Blackburn, Lancaster, for "certain Improvements in machinery or apparatus for carding, drawing, slubbing, and roving cotton wool and other fibrous substances."—Dec. 14.

James Carter, of Oldham, Lancaster, painter, for "an Improved lubricator."—Dec. 14.

Charles Ford, of Shelton, Stafford, engineer, for "Improvements in the manufacture of pottery or earthenware, and in the tools, instruments, or apparatus employed therein, part or parts of which improvements are applicable to other similar purposes."—Dec. 14.

Henry Bleasdale, of Chipping, Lancaster, roller-maker, and William Ryder, of Bolton, in the same county, roller-maker, for "certain Improvements in machinery or apparatus to be employed in the manufacture of rollers used in machinery for preparing and spinning cotton and other fibrous substances."—Dec. 14.

John Todd, of Glasgow, engineer, and William Johnson, of Birmingham, engineer, for "Improvements in arranging the rails on certain parts of railways."—Dec. 14.

John Chubb, of St. Paul's Churchyard, City, for "Improvements in locks and latches to be used for fastenings."—Dec. 14.

Benjamin Vickers, of Sheffield, Yorkshire, merchant, for "an invention called the mechanical chirographer, or machine for delineating letters, figures, and other characters." (A communication.)—Dec. 14.

Jeremiah Campion, of Somers-place, Hyde-park, Middlesex, gentleman, for "Improvements in soldiers' belts, and improvements to facilitate the carrying of knapsacks."—Dec. 15.

Thomas Friend Dickinson, of Newcastle-upon-Tyne, sharebroker, and John Falkous, of the same place, gas engineer, for "certain Improvements in gas metres."—Dec. 15.

Mark Bingley, of Cannon-street, London, stationer, for "Improvements in bookbinding, and in weaving materials used in bookbinding, applicable also to other weavings, and in preparing for, and making alphabets for account and other books, and in inking type therefor and other purposes, and in preparing sprinkled, granulated, or mottled paper for bookbinders and others, applicable also to the edges of books, and in graining or chequering Russia or other leathers."—Dec. 15.

Richard Turner, of Hammersmith Works, Dublin, and Bath-place, New-road, Middlesex, for "Improvements in the construction of roofs of railway stations, and roofs and floors of other buildings."—Dec. 15.

Walter Smart, junior, of Leather lane, Middlesex, lithographic printer, for "a new or improved lithographic printing press."—Dec. 21.

John Watson, of Glasgow, manager to Messrs. Gilmour and Kerr, power-loom cloth manufacturer, for "Improvements in weaving by Jacquard looms by power."—Dec. 21.

Peter Borrie, of the Crescent, Minories, City, engineer, for "Improvements in the construction of piers and harbours."—Dec. 21.

John Jennings, of Ollerton, Cheater, farmer, for "certain Improvements in machinery or apparatus for threshing."—Dec. 21.

Richard Boyce Osborne, of Limerick, Ireland, civil engineer, for "certain Improvements in bridges, roofing, and flooring." (A communication.)—Dec. 21.

Louis Sylvian Gonin, of Paris, manufacturer, for "Improvements in printing stuffs, paper, and other matters."—Dec. 21.

Moses Poole, London, gentleman, for "means and apparatus for administering certain matter to the lungs for medical or surgical purposes." (A communication.)—Dec. 21.

Joseph Whitworth, of Manchester, engineer, for "Improvements in machinery for knitting."—Dec. 21.

Augustus Applegarth, of Dartford, Kent, calico printer, for "Improvements in machines for printing paper and other fabrics."—Dec. 21.

Moses Poole, London, gentleman, for "Improvements in steam-engines, and machinery for propelling machinery and fluids." (A communication.)—Dec. 21.

Antoine Perpigna, of Paris, advocate, for "certain Improvements in machinery for plaiting and braiding." (A communication.)—Dec. 21.

John Perry, of Leicester, wool-comb manufacturer, and James Noble, of the same place, wool-comber, for "certain Improvements in combing wool, and in preparing wool for combing and carding."—Dec. 21.

Pierre Frederic Gougy, of Leicester-square, Middlesex, gentleman, for "Improvements in apparatus and machinery for raising, lifting, and otherwise moving heavy bodies."—Dec. 21.

TO CORRESPONDENTS.

Sir Howard Douglas requests us to state that he will in a short time reply to the observations on the Strength and Stability of Hungerford Bridge, in our last (December) number.

H. S.—The second letter was, we suppose, intended to prevent the publication of the first, which would otherwise have been inserted. Perhaps our correspondent will write again after reading the letters on the subject in our present number.

Received: "Ancient and Modern Architecture;" "Life of Gandon;" X Y Z, North Wales,—Next month.

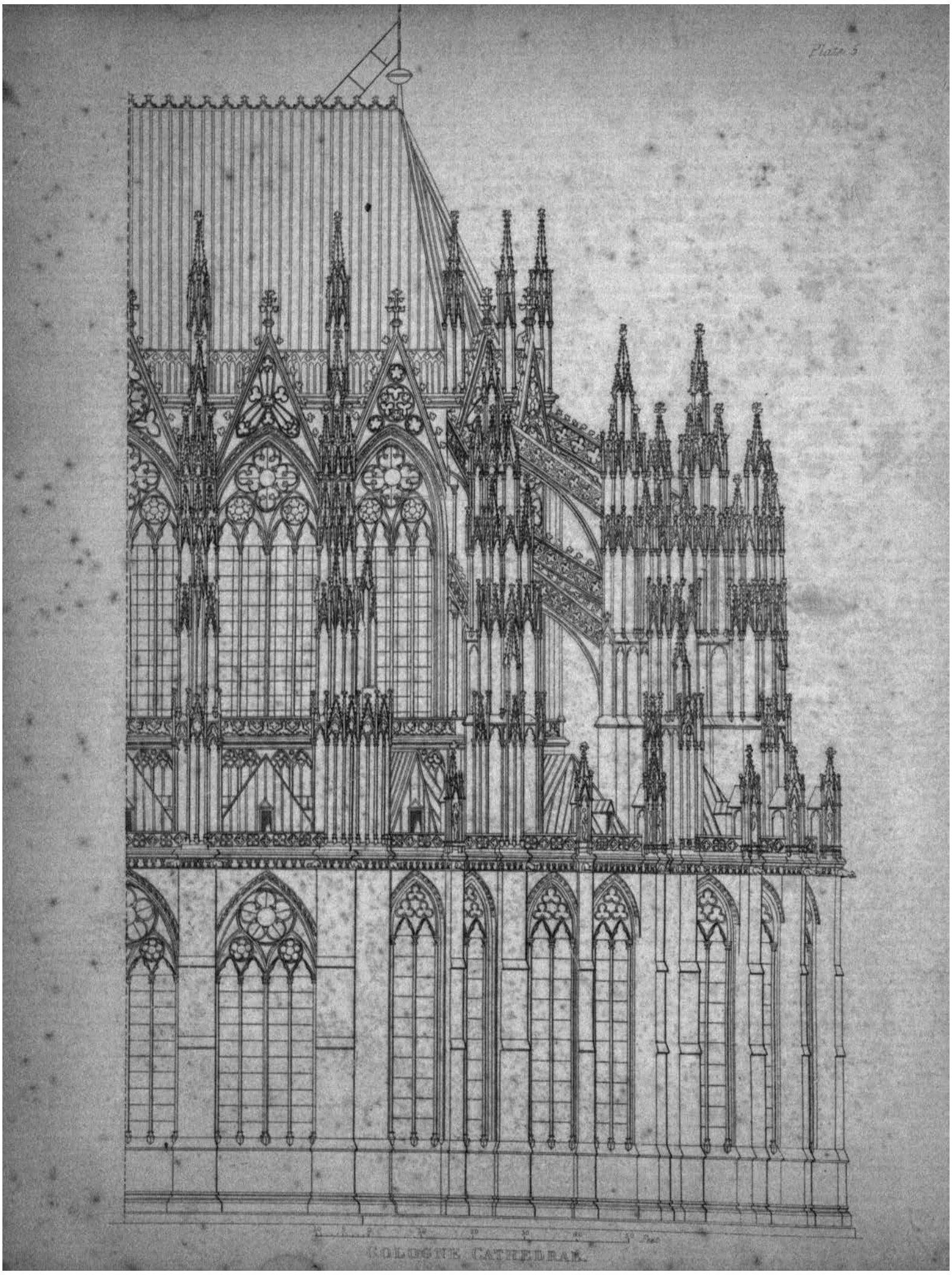


Plate 5
COLOGNE CATHEDRAL.

COLOGNE CATHEDRAL.

(With an Engraving, Plate V.)

It is not a century since Christian architecture was praised for its barbaric magnificence. The admiration accorded to it differed in degree, but was identical in nature, with that given to the grotesque Indian pagoda, or the fantastic extravagancies of Louis Quatorze. Vitruvius had reduced the proportions of temple architecture to numerical calculation, and shown how many times the height of a column should exceed its width: but as there was no book extant in which cathedral architecture was similarly treated, it was condemned as unsystematic and inharmonious. The plumb-line and foot-rule were then the critic's stock-in-trade; with these implements the "noble art of criticism" was worked out with all the mechanical precision of plane surveying.

After a time, however, the bright thought was suggested that, perhaps, the mediæval architects were not the barbarians they had been taken to be; that, with all their caprices and apparent defiance of rule, there might be some method in their madness, if it could but be found out. It was questioned whether there might not be other harmonies more subtle than those which are capable of being settled by the multiplication-table. And when these heresies in architecture had once been started, they were not forthwith silenced as visionary; but, on the contrary, spread and multiplied exceedingly. It is true, that the orthodox Academies and "legally constituted authorities" had nothing to do with the promulgation of the new doctrines, and that one of those Royal Societies who have been kind enough to undertake the protection of art—namely, the Académie Royale des Beaux Arts at Paris—did in its wisdom pronounce, in June 1846, a strong anathema against the revival of Pointed architecture. But, notwithstanding the resistance of this and other very solid bodies to external pressure, it has become more or less evident to all who are concerned in the matter, that the opposition, whether passive or active, was quite too late and might be safely disregarded.

Now, among all who love Art for its own sake, and who can, therefore, appreciate its existence independently of the aid of arithmetic, a general conviction seems to be growing up, that the most eloquent defence of their doctrines has been set forth on the banks of the Rhine. Universal consent appears to point to the fact that *there* stands the noblest and mightiest of all monuments of mediæval thought and skill.—The Cathedral of Cologne, wasted by time and the elements, despoiled by French soldiery, despised by classic connoisseurs, and neglected by its own proper guardians, has come to be considered the most beautiful of poems which man's hand has ever written in stone.

But this builded poem, though it excel all others in beauty, is yet one of the least complete; so to speak, only a few books of it remain, and those have been sadly marred by the notes and emendations of commentators. Accordingly, the promulgators of the new architectural doctrines were desirous to repair the injuries which false friends and professed enemies had inflicted upon Cologne. But the work of reparation had scarcely been begun, before it was found out that another work, far more magnificent, might be attempted with every prospect of success—namely, that of completion. Now, in order to comprehend the magnitude and boldness of this project, it is requisite to understand clearly the original plan and design of the building, and to what extent the intention of the first architects had been carried into effect.

The design of the building comprehended, in the first place, two enormous towers at the west end, surmounted by spires; and this part alone, as it surpassed in magnitude everything similar to it in the world, so also would have been superior in the costliness of its decorations. For the spires were each to have attained the height of 536 feet—a height nearly double that at Lincoln, and exceeding that at Salisbury by 132 feet; and the profusion and delicacy of sculpture would have outvied Strasburgh itself. The height of the nave internally was to have been 150 feet, and some idea of its magnitude may be formed from the assertion, that it is of sufficient capacity to contain the Chapel of King College, Cambridge, completely within it. The nave at Cologne was to have double aisles, including which, its total breadth would be the same as its internal height, namely 150 feet. The approximate equality of the breadth and height of the nave is observed in most of the English cathedrals.

Besides the parts described, there were double transepts, and beyond them the stately choir delineated in our engraving, which is the only complete part of the building. The external height of the choir is 208 feet—as nearly as possible the height of the *towers* of Westminster Abbey!

The total length of Cologne Cathedral is not very great compared with its width, being 500 feet. In this respect it is exceeded by three of our own cathedrals—Winchester, Ely, and Canterbury, and equalled by two others—York and Lincoln: and it is curious to observe, that while in these edifices the length is six or seven times the breadth, in the great continental church the length is only three times and one-third the breadth.

Of the vast pile thus contemplated, comparatively little has been actually executed. The choir, as we said, is the only complete part. In each transept a portion of the east walls is erected. Of the nave little is built, and there exists a great gap, which is covered in by temporary walls and roofs: the northern aisles are in the most perfect condition, seven compartments in their roofs being groined over, and the windows being finished and filled with stained glass; but in the southern aisle the windows had only reached the springing of their arches. In the grand western facade of the cathedral there is a large vacant space between the north and south towers; and of these towers, the southern only had reached to the height of the nave and choir-roofs, the northern being only just commenced.

It will be seen, therefore, that the work of completing this Cathedral excels in magnitude that of erecting almost any other. And this consideration alone can give us an adequate notion of the boldness and enthusiasm which must have actuated the Germanic nations when they undertook this gigantic task: for though the mere magnitude of the work may be understood from the foregoing dimensions, their variety and intricacy can only be ascertained from minute local inspection. The tracery is different in every window (the manufacture of "Gothic windows" at so much a dozen being a somewhat later invention). The whole structure, as may be seen from the view of the choir, would tower above a forest of finials, pinnacles, and flying buttresses. Every part seems literally covered with the luxuriant overgrowth of delicate sculpture—rich canopies for figures of the saints, crockets carved into the semblance of roses with the minuteness of nature; every beautiful form which Flora could suggest, and every strange form which a fantastic imagination could create, seem here embodied in stone. Amidst flowers and foliage and clustering fruits, appear strange fabulous monsters, dragons, griffins, and winged unicorns. The demons and hobgoblins who, as every one knows, used in olden time to play such terrible pranks about the mountains of the Rhine, here live again, long after the printing press and the steam engine have laid them low.—As you walk round the building, look up suddenly, and you will probably see some fantastic merry devil grinning at you from beneath a water-shoot or corbel; suddenly turn the angle of a buttress, and you find that a troop of little imps have been watching you round the corner: while within the gorgeous choir, solemn figures of the saints look down from their lofty niches, and gigantic angels seem to hover high up above the altar. Towards dusk, it requires strong nerves to look at these mysterious forms without awe, for they gain in apparent size, and look tenfold more mysterious, in the twilight; and no one, probably, would like to be locked up all night in Cologne Cathedral, with no other company than these saintly effigies, the sepulchral monuments, and the reliques of the Three Kings.*

* The account of the works of Cologne Cathedral will be continued, with additional Engravings: for the one now presented to our readers we are indebted for the original to "Gailhabaud's Ancient and Modern Architecture."

HALL OF LIBERTY (LIBERATION), KEHLHEIM.

It is not only by its pregnant historical and ethic character, but by the massiveness and sterlingness of its architectural conception, that this monument (called forth by the will of the King of Bavaria) deserves especial attention. Thus, Liberty Hall, with its huge bronze memorial tablets, will infuse new ideas and thoughts in the mind of nations, which, however they may be imparted, we are much in need of.

Kehlheim is situated about four leagues above Donaustauf; opposite which latter place the Walhalla reflects its shadows in the waters of the Danube. Celebrated for years past by its valuable limestone quarries—another consideration has induced Lewis I. to select it for the site of his new creation, viz., it being the place where the Ludwig canal disembogues into the Danube. In the nearly right-angle space which the river and canal form here, the *terrain* ascends considerably, and forms, towards the Danube, an elevated steep wall of rocks. It is on this commanding plateau that Liberty Hall is being erected. The main structure, a huge rotunda with a dome ceiling, forms a *octo-decagon* (*Achzeneck*) of 206 feet diameter in the greatest width of the hall, exclusive of the outer groined vaulted arcade that surrounds it; the outer hall abuts to a height of 60 feet (including a flat roof) against the dome structure, and round the outer vaulted hall extend the groined vaulted arcades, of a joint height of 22 feet, including the groining. The building will rise, up to the highest point of the lantern in the cupola, to the elevation of 175 feet. The height from the vaulting to the entablature is 100 feet. Beneath the latter extends the outer triumphal-area, consisting of double arch-openings, separated by two pilasters, all round the octo-decagon. Above the entablature, three steps surround the outer dome vaulting.

The stairs, from the entrance, lead up to half the height, straight to the main building; they then branch off, laterally, in two ascents. If, therefore, we step in the centre of the building, we are surrounded by a cycle of columns, whose diameter, from the centre of one column to the opposite column, through the diagonal of the rotunda, measures 100 feet. Eighteen columns rise from the floor, on the radii of the octo-decagon. They are monoliths of granite, and measure (including bases and capitals, of white marble) 27 feet, and have a diameter of 4 ft. 4 in. Above these, spring circular arches with archivolts, also of white marble, and the eighteen mural surfaces above them are of yellow marble; on these are inscriptional tablets of white marble. The space above the eighteen mural surfaces is divided by double arch openings, with pilasters and semi-columns. Behind these, extends the inner triumphal area. Above these arch-openings of the inner triumphal area, the vertical portion of the building extends to a height of 84 feet above the inner floor. The inner dome vaulting rises thence to a height of 30 feet up to the lantern, whose diameter in the clear, is 31 feet. Behind the circle of columns, on the ground floor, extends an arcade with groined vaultings, which the architect intends to dress with dark red marble, the effect of which will be surprising. This arcade is surrounded by a cella-wall of 8 feet thickness, which latter divides the inner from the outer arcade. According to these measurements, the plan, elevation, and sections of this gigantic structure may be easily conceived.

This huge rotunda and cupola structure is merely destined to be the shell of its internal, strictly monumental, kernel. If we again go to the centre of the podium of the hall, under the lantern of the cupola (which *alone* will light this huge space), we shall see ourselves surrounded, at the distance of 40 feet, by a ring-formed stylobate, which has no entrance, save by one opening, opposite and in a right line to the main entrance of the hall. On this (continuous) stylobate, stand, in a circle, *thirty-four colossal* Victories, in pairs, close to each other, before the columns, and holding each other with one hand; with the other, each pair grasps a bronze shield, made of the enemies' cannon. On the gilded front of these shields are inscribed the names of the different battles, &c., and the names of the leaders will be put in the corresponding marble tablets on the same wall-face of the octo-decagon. The backs of the shields will not be gilded, for the purpose of showing the metal they are made of. The winged Victories are each 10 feet high, and of white marble, and form, with the mass of shields which they bear, an unterrupted and most imposing circle; this being only open at one place—the main entrance. They are to be made after models of Master (*sic*) Schwanthaler.

In conclusion, it is to be remarked, that the king of Bavaria has ordered that not one piece of wood is to be used in this structure, which will consist entirely of Kehlheim limestone, granite, Slander's marble, iron, and copper, with which latter metal the cupola and the entrance-hall will be roofed. The very foundation of the walls had to extend, at places, to the depth of 50 feet, owing to the inequality of the *terrain*, is, in itself, a vast complex of numberless arches and vaults, well worthy the attention of builders. The ingenious manner in which the architect has executed the double vaulting of the dome is not to be passed over in silence. The name of this worthy master is Sir Frederick Gaertner, P.R.A. of Arts at Munich.

J. L——y.

DISCOVERY OF TERMESSUS.

The site of Termessus, one of the largest and most important cities of Asia Minor, has long been a matter of doubt. The recent travels of Lieut. Spratt and Professor Forbes in Lycia, have however settled the dispute, and to these enterprising travellers we are indebted for a discovery of great interest in an architectural point of view, and one which adds to the records of ancient art a whole city filled with Roman edifices, many of them very important and in an excellent state of preservation. Of these, one of the principal is the ancient theatre, which is minutely described. The nature and extent of the discoveries will be seen from the following narration:—

"The valley became more and more confined. We were evidently entering an important pass; every here and there were traces of fortifications: suddenly, in the narrowest part of the gorge, we came upon a range of perfect and admirably built Hellenic walls, stretching across it, fortified by towers, and passable only by the ancient and narrow pathway. The fortifications mentioned by Arrian, the pass through which the army of Alexander marched, seemed before us, and at every turn we expected to see the walls of Termessus. Our guide pointed to the summit of the mountain above us, and said he had heard of ruins there. About a mile beyond the gateway, we reached a khan, consisting of three stone buildings, and a coffee-house, kept by Turkish soldiers, acting as guards to the pass. Here we put up for the night, not a little gratified by the assurance given us by one of these men, that the report of ruins on the neighbouring mountain was true.

Early in the morning we commenced the ascent of the mountain, to seek for the ruined city. The first part was over steep and rocky ground, but after a time we came upon an ancient roadway, leading towards an opening in the mountain side between two towering rocky peaks. Following this road, which was buried in trees, and encumbered by underwood, for an hour and a half, we suddenly came upon two ancient guard-houses, almost perfect, one on either side of the way. We did not linger to trace any connecting wall, but hurried anxiously on with sanguine expectations. For nearly a mile we met with no other traces of ruins; some sarcophagi were at length discovered among the thicket, and near them, on the face of a great rock, were carved in large letters, the words ΠΛΑΤΟΝΙΚΟΣ ΦΙΛΟΣΟΦΟΣ.

Suddenly, after crossing a low wall, we emerged from the thicket, and entered an open and flat area between the two great rocks, and walled in by inaccessible precipices. On it ruins were profusely scattered; numerous tombs and sarcophagi, fallen buildings of large size, and a temple, the ornamented doorway of which still stood, fronted by a goodly flight of steps. Fluted columns of large dimensions lay strewed in fragments upon the ground. Unwilling to delay until we had ascertained the full extent of the city, after a hasty glance we proceeded to the upper end of the platform. Here the valley became more contracted, and a strong and perfect wall was thrown across it. Within this, ruins of nobler style and more perfect preservation appeared, especially a palatial building of great extent, having numerous doors and windows, and almost perfect to the roof; like the others, it was constructed of rectangular blocks of limestone, without intervening cement; before us, on what appeared to be the mountain top, a third wall appeared, to which we ascended, expecting to find the acropolis. Hitherto we had met with no mention of the city in any of the inscriptions, but, on ascending to the last-mentioned wall, we came upon an inscribed pedestal, which assured us we were in Termessus, a name shouted out by the finders with no small delight, and echoed by the old rocks, as if in confirmation. It must have been new to them after

having rested so long unspoken. On reaching the third wall, our surprise was great at finding that hitherto we had been wandering as it were only in the vestibule of the city, and that Termessus itself was yet to come, built on the mountain top, even as Arrian has recorded. It stood on a platform, surrounded by a natural wall of crags, three to four hundred feet high, except on the east, where it terminated in a tremendous precipice, diving into a deep gorge, opening into the Pamphylian plain.

After crossing the third wall, our attention was first attracted by an avenue, bordered on each side by a close row of pedestals, terminated at each end by public buildings, apparently temples. These pedestals were almost all inscribed, and the inscriptions in good preservation. One of them was of peculiar interest, confirming this site as Termessus Major, ΤΕΡΜΗΣΣΕΩΝΤΩΝ ΜΕΙΖΟΝΩΝ ΠΟΛΙΣ.

Above the avenue to the west, appears to have been the habitable portion of the city,—the buildings there, which are all fallen, having the aspect of the remains of dwelling-houses. To the south and east the ground is covered by public edifices, many in tolerable preservation, others prostrate,—all of substantial architecture. In the centre is an open levelled space, which, from an inscription, proved to be the Agora. In the midst of it stands an isolated rock, about fifteen feet high, surmounted by a plain sarcophagus, below which, at the head of a flight of steps, hewn out of a rock, is a recess with a seat (a Bema?). There are also niches for votive tablets. The area of the Agora is undermined by extensive cisterns, the roofs of which are supported by massive pillars and arches. This area seems, during the Middle Ages, to have been inclosed by the walls and cells of a monastery, one of the very few remains of Christian origin at this site. Termessus was the seat of an episcopal see. Around the Agora are the most important public buildings; the most perfect of these is a great square erection with highly finished walls, ornamented with Doric pilasters, and having only two windows, placed high up. A smaller and similar building stands behind the larger, the most prominent object among the ruins, and by its side a second, in front of which are two pedestals, bearing inscriptions, one in honour of Plato, who appears to have been held in high esteem by the Termessians, and the other dedicated to the Muses, of whom this was probably the temple. By the side of the Agora, and on the left of the great square building, are the fallen remains of a Doric temple, apparently (from an inscription) dedicated to the sun. Some of the blocks are of Parian marble, and are fragments of sculptured friezes. A search and excavation among them would most probably lead to the discovery of many works of art."

ANCIENT SYRACUSE.

Paper read by S. Angell, Esq., *at the Royal Institute of British Architects, Jan.* 11, 1847.

The ancient Syracuse occupied the first rank of all the cities of Sicily, or Magna Græcia, in point of extent and political importance; and there are few remains of ancient cities, even in Greece herself, which are more interesting to the scholar or the antiquary.

I visited the ruins and the modern city in company with some fellow-students in the summer of 1822. The classical interest of the spot, the beauty of the situation, and the splendour of the climate (noted by Cicero for its sunshine in every day of the year) were such, that not even a week's painful imprisonment in the quarantine, on a subsequent occasion, could diminish my feelings of admiration for this renowned spot.

The present paper being principally devoted to the architectural description of the ancient city, I will not occupy the time of the meeting with a long account of its history: it will be sufficient for our purpose merely to refer to the tradition of its having received its inhabitants, in very early ages of the world, from Egypt and Phœnicia; that they were driven out by the Siculi, who, in their turn, were replaced by a colony from Corinth, led by Archias, one of the Heraclidæ, in the second year of the eleventh Olympiad, or about 732 years before the Christian era. The city was named by them Ortygia, or the island of quails (the same name was originally given to the island of Delos).

We have the united testimony of ancient historians and poets to the effect, that the city rapidly increased until it arrived at so great an extent, and to such a degree of splendour, that Thucydides (long before it reached its summit of prosperity under Dionysius) acknowledged it to be equal in size to Athens; and Cicero mentions it, in one of his orations, as the *largest* and most magnificent city in Greece.*

The city was under different governments until freed from the tyranny of Thrasybulus, 446 B.C.; and sixty-one years afterwards it was usurped by the Dionysii, who were expelled by Timoleon, 343 B.C. The celebrated part it took in the wars with Carthage, its memorable conflicts with the Athenians, and its sad and mighty fall, after enduring a three years' siege by the Roman conqueror, Marcellus, are events so well known to every scholar, as to require no further allusion to on my part at this meeting.

In after years, the Saracens completed the ruin the Romans commenced; and A.D. 827 Syracuse resigned to her rival, Palermo, the proud title of Capital of Sicily. From that time the city has dwindled into comparative insignificance. Her population at the present time does not exceed 12,000; and that commerce which once filled its glorious harbours with the ships of Rhodes, Alexandria, and Carthage, is now confined to a few speronaras engaged in a miserable coasting trade.

Syracuse is said to have derived its name originally from the neighbouring Marsh Syraco (now called *Il Pantano*), and situate on the right bank of the Anapos: it was afterwards called *Tetrapolis*, a city formed of *four* distinct quarters, and these were named *Ortygia*, *Acradina*, *Aycha*, and *Neapolis*.

According to Strabo, the circuit of the ancient walls was 80 stadiæ, or 22½ miles, including the suburb of Epipolæ, which was to the westward of Neapolis, and commanded the whole city. At the extremity of Epipolæ was an almost impregnable fortress, called Euryale, mentioned by Livy, and other historians.

The great port of Syracuse—one of the finest in the Mediterranean—is about five miles in circumference. As you enter from the ocean, to the left hand is the rock Plemmyrium, distant from the opposite shore of Ortygia about half a mile. It was across this entrance to the port that the Syracusans, by advice of Hermocrates, threw a strong chain, and thus blockaded the Athenian fleet.

In modern times, the great port of Syracuse has its name connected with a glorious event; for it was here that Nelson revictualled his fleet previous to the battle of the Nile. The lesser port is on the other side of the island Ortygia; it was called Portus Marmoreus, according to some authorities, from the bottom having originally been paved with marble; but perhaps with more probability from the costly buildings which lined its shores.

I will now endeavour briefly to describe the four quarters of the city, commencing with the most ancient one. Ortygia was formerly considered the most important part, in consequence of its commanding the entrance to both the ports. The tyrants established their residences in this division, and added, from time to time, to the fortifications. The Romans also, when masters of Syracuse, regarded the situation of Ortygia in the same important light, and prohibited any native citizen from residing in that portion of the city.

The Temple of Minerva was the most sacred and important building in Ortygia: it now forms the cathedral, or duomo, to the modern city, to which purpose it was converted during the 12th century, when the Goddess of Wisdom was obliged to resign her shrine to "Our Lady of the Columns;" for such was the change in the dedication of this edifice.

The temple was of the Doric order, peripteral and hexastyle, with fourteen columns on the sides. The lower diameter is about six feet seven inches, and the height twenty-eight feet ten inches. The character of the order resembles the Agrigentine examples.* Twenty-one columns of the Peristyles, with portions of the entablature, are still standing; but, unfortunately, they are built up in the outer walls of the duomo. The two columns of the Posticum also remain. The columns, unfortunately, have been disfigured with modern plaster and additional mouldings; and it is much to be regretted that these, by some oversight, have found their way into an important work on Magna Græcia, and are there shown as part of the ancient work. It was only after much entreaty and persuasion, and offering ample security, in case of injury, that the church authorities (who, unfortunately, in Sicily, are not so devoted to archæological pursuits as the clergy in this country) gave us permission to raise a scaffold, and clear away these unseemly encumbrances.

Cicero has given us an excellent description of the gorgeous magnificence of this temple, which, spared by the piety of Marcellus, was stripped of every thing but the roof and walls by the rapacious Verres. "Its doors," says the Roman orator, "were the theme of universal eulogy, exhibiting the labours of Hercules, curiously wrought in ivory, the angles of each separate panel being adorned with golden bosses of exquisite workmanship, while a Medusa's head, formed of the same rich material, shone above the portal, surrounded with its bristling snakes." We learn also from Athenæus, that upon the exterior summit of the roof was elevated an enormous shield, consecrated to Minerva, and visible to a great distance by the reflection of the solar rays. A custom prevailed among the Syracusan sailors, to

* Urbem Syracusas maximam esse Græcarum urbium pulcherrimamque omnium saepe audistis.—Cic. Orat. 2, in Ver., lib. iv.

* I have shown the capitals half the real size. The anta cap may be considered as a good example of the favourite Becco di Civetta, or Owl's Beak moulding of the ancients.

secure a safe return from their voyage, of carrying from an altar near the Temple of Juno some ashes in a chalice, which, with flowers, honey, frankincense, and other aromatics, they cast into the sea as soon as they were about to lose sight of this shield. The interior of the walls of this temple were covered with paintings, amongst which was an equestrian combat of King Agathocles, one of the most esteemed works of Syracusan art; this, with twenty-seven other admirable pictures, did the unscrupulous Verres carry away. According to tradition, Archimedes drew an equinoctial line in this temple, and Mirabella says that in 1582 the commissioners appointed by Pope Gregory for the correction of the calendar came to Syracuse for the purpose of examining it. This building has suffered much from earthquakes, but I strongly suspect the hand of man has been the great destroyer: the modern façade of the Borromini school forms a strange mixture with the rigid Doric of the ancient peristyle.

Of the Temple of Diana, two Doric columns with a small portion of entablature alone remain. To judge of the effect of them is no very easy matter, for the columns are unfortunately encased by the walls of a modern dwelling, and the capitals are absolutely inclosed in a wretched closet. Notwithstanding this sad modern degradation of the great Diana's fane, these scanty remains possess considerable degree of interest, as belonging to the most ancient temple of Ortygia; and it is a curious circumstance, that the style of the columns, with the bold swelling capital, strongly resembles the order at Corinth, the mother city. The Selinus and Pæstum examples have also a great resemblance to it. The intercolumniation must have been very small, there being only 1 ft. 6½ in. between the abaci of the two capitals. I am happy to state, that since my visit to Syracuse, the Duke of Serradifalco (a nobleman so well known to us all for his successful architectural researches in his native country, and for his contributions to the library of the Institute), has discovered the lower portions of these columns. Near this temple stood the celebrated Baths of Daphne, so named from a laurel grove sacred to Diana: the spot is now called Bagnara, and many remains have been discovered near it.

The celebrated fountain of Arethusa next claims our attention. This classic spot, sacred to the nymph to whom divine honours were offered, and upon whose shrine even Hercules sacrificed, still pours forth its abundant supply of fresh water as of old, but alas how different its present state! It is now the public washing place of the town; and when I saw it, a number of Hungarian soldiers were lounging about it, enjoying their merschaums, unconscious of the fame of the spot, or of the gibes and wit that the Syracusan laundresses were indulging in at their expense.

According to Diodorus, the celebrated building, the palace of sixty couches, which in magnitude and splendour was so superior to the temples, that the gods, from jealousy, are said to have destroyed it by thunder, was situate in Ortygia. This, together with the palace and gardens of Dionysius, the citadel surrendered by Dionysius to Timoleon, the Palace of Hiero, afterwards the residence of the Roman prætor and proconsuls, and the workshops of the infamous Verres, have all disappeared, and their sites are now occupied with modern fortifications, and narrow streets of miserable dwellings.

I now proceed to the adjoining quarter of the city, called Acradina, described by Cicero "as the second city, containing a spacious forum, a beautiful portico, and an ornamental prytaneum, or public hall, from which Verres stole the inimitable statue of Sappho, the great work of Silanion." Of these buildings there are now no existing remains. It is, however, probable that the Church of San Giovanni occupies the site of an ancient temple; and Mr. Hughes, in his admirable and elaborate description of the city, supposes it to have been the Temple of Jupiter, in which Hiero suspended the Gallic and Illyrian spoils presented by him to the Roman senate; and from a passage in which Cicero upbraids Verres for allowing a piratical corsair to sail into the port, and penetrate up to the very forum, we may infer that the forum was placed near the Isthmus.

In this quarter of Acradina are several of those Latomiæ, or stone quarries, which are so numerous in Syracuse. The most remarkable one is perhaps the one attached to the Capuchin convent, and now converted into a garden, forming one of the most beautiful and retired spots that possibly could be selected for devotional study.

There are also various subterraneous remains in this quarter, with vaults constructed of earthern pots, and the ruins of a bath excavated by Landolina, in 1804, in which was found the beautiful Torso of Venus, now forming the most valuable specimen of ancient sculpture to be found in the museum of the modern city.

The celebrated catacombs are in the quarter Acradina, and whether they are the works of the Syracusans previous to the Roman conquest by Marcellus, or subsequent to that period, is still a matter of conjecture. Mr. Hughes is inclined to attribute them to the Romans. At all events they are prodigious works. Denon describes them as a perfect subterranean city. The principal street or avenue in the catacombs is about eighteen feet wide and ten high, with numerous recesses and chambers on either side, with separate receptacles for the bodies, in one of which I counted no less than fifteen divisions. Swinburn relates that he saw a gold coin of the time of Icetas just taken out of the jaws of a body found in a tomb here; this must have been the *Naulon*, or Charon's fare.

Along the main street, at intervening distances, are transverse streets, forming at their intersections square and circular apartments, which are generally vaulted, and in some of them are conical apertures for light and air. Around these chambers are numerous recesses, symmetrically formed. In some parts the walls are covered with fine stucco, and there are the remains of painting, with monograms and symbolical devices, the works probably of the early Christians. An old Capuchin monk acted as our cicerone in going through the catacombs, and the effect of his slow and solemn step, and the glare of the torches through this city of the dead, will not be readily effaced from my memory.

Of the walls of Acradina there are still remaining considerable vestiges, and the rock itself is in some places formed into battlements.

Not far from a gap in the rock, called Scala Græca, where the quarter of Acradina terminated, and that of Tycha commenced, may be traced one of the principal gates of ancient Syracuse, and which, like some of the other gateways, was admirably contrived for defence, the assailants being forced to expose their *right* side, which was unprotected by the shield, to a great length of wall, and the missiles of its defenders.

From Scala Græca a broad road traversed the city to the point Ortygia, lined on each side by strong walls and towers. Fazello states, that a little beyond it, in the quarter of Tycha, stood the town called Galeagra, where a Roman soldier, during the conferences of Epycedes and Marcellus, by numbering the courses of stone and computing their height, found the wall much lower than common opinion, and scalable by the ordinary ladders. By these means Marcellus took the city in the night, during a festival of Diana, when the inhabitants, more attentive to their superstitious observances than the means of defence, were in a state of great intoxication.

The quarter, Tycha, is described by Cicero as the third city; and he says it was so named from the Temple of Fortune within its precincts, and that it contained a spacious Gymnasium, and many sacred edifices. Of this once splendid quarter of the city little now remains, excepting large sepulchres cut in the rocks, channels of aqueducts, and vestiges of the city walls. To account for so large a space being so completely cleared of the remains of the numerous buildings which formerly occupied it, one is almost led to the supposition that, from the facility of transport given by the immediate vicinity of the port, the materials must have been transported to other shores.

Neapolis is the fourth quarter of the city mentioned by Cicero, and, as its name implies, was the last built. It was adorned with a theatre of vast dimensions, two superb temples—one of Ceres and another of Proserpine—and a very beautiful colossal statute of *Apollo Temenites*.

The theatre is perhaps the most perfect of all the ancient buildings of Syracuse. It was the largest in Sicily, and is computed to have contained 30,000 persons. Its situation, on a rising ground, commands a magnificent view over the ports and surrounding country. The greater portion of the seats are cut out of the living rock.

In my examination of this edifice I had the great advantage to possess the elaborate and careful studies made in the previous year by Professor Donaldson; and as these have been given in so admirable a manner by that accomplished architect, in the supplementary volume of "Stewart's Athens," it is unnecessary for me to attempt a further description of a work already so familiar to the members of this Institute.

Above the theatre are numerous excavations in the rocks, remains of water courses, streets, and sepulchres. One, more perfect than the rest, is called the Tomb of Archimedes; and although the sepulchral stele, with the sphere and cylinder carved upon it, are no longer to be found to authenticate its identity, one feels unwilling to doubt that this must be the very monument discovered by Cicero, and pronounced by him as the sepulchre of the immortal Archimedes.

Not far from the theatre are the remains of an amphitheatre, which was also in part excavated from the platform of living rock. The arena, seats, corridors, podium, subterranean cells, and water-ducts are still easily traceable. The construction is evidently Roman.

The extensive quarries, or Latomiæ, are principally in this quarter of the city. They are said to have been excavated by the Athenian prisoners, and afterwards used as places of confinement. No greater contrast can be imagined than their former with their present state;

for those once gloomy abodes of the victims of Dionysius are now flourishing with the luxurious vegetation of the pomegranate and the orange, and are watered by the transparent streams which still flow along the ancient channels; and the spot where the infamous Verres incarcerated not only Syracusans, but Roman citizens, is now termed "*Il Paradiso.*" In this Latomia is the church of San Nicolo; under which is a chamber excavated from the rock, 64 ft. 6 in. long, 22 ft. 6 in. wide; and from the remains of a water-duct at one end it was probably used as a reservoir.

I must not pass by the curious cavern called the ear of Dionysius, which is about 170 feet in depth, 35 feet in width, and 60 feet in height. It is stated that Dionysius constructed this cavern on acoustic principles, for the purpose of overhearing the conversation of the prisoners confined within its walls. There is beyond doubt a wonderful power of conveying and increasing sound in this curious vault; but an examination of it, including the somewhat hazardous ascent with ropes and pullies to the cavity near the top, impressed us with the notion that this power, as is the case with most echoes, is more to be ascribed to accident than to art.

Neapolis was also adorned by a colossal statue of Apollo Temenites, which stood proudly pre-eminent on a rising ground, and was preserved, says Cicero, by its magnitude, from the sacrilegious grasp of Verres. Suetonius states, that it was contemplated by the emperor Tiberius to place it in the library which he had built, or restored, in honour of Augustus; but that he was prevented by the Deity in a vision.

The ruins of the Temple of Jupiter Olympius are situate on a gentle eminence on the right bank of the Anapus, overlooking the great port. Portions of the shafts of two Doric columns alone remain standing; but I am rather doubtful whether these are in the original position. It is to be much regretted, that so little is left of this temple, which, in its original state, was described as the richest monument in Syracuse. In its adytum was placed the famous statue of Jupiter, esteemed one of the three* most noble representations of that deity ever produced, and from which Dionysius stripped off the golden mantle, replacing it with one of wool, accompanying his robbery with the impudent apology, that gold was too heavy in summer and too cold in winter for the king of the gods, but that wool was adapted for both seasons.

I believe I have now generally, though I fear very imperfectly, described the principal remains of the four quarters of the ancient city; and I will trespass for a few minutes longer only upon the attention of the meeting, by making some short observations upon the suburbs and outworks.

Epipolæ, so celebrated in the sieges of Syracuse, is to the westward of Neapolis, on a spot (as its name imports) commanding the whole city. It was inclosed by Dionysius within those remarkable fortifications and walls said to have been constructed by him in the incredible short space of twenty days, and upon which he employed 60,000 workmen and 6,000 yoke of oxen.

It was also defended by a fort, which, according to Fazello, was called by the Greeks Labdalo, but Mr. Hughes is of opinion (judging from the descriptions of Thucydides and Dioduras) that Labdalo was considerably lower in the descent, and that the fort in question was the celebrated Hexapylon, a work constructed with extraordinary military skill and art. Mr. Cockerell (and I cannot appeal to a higher authority in these matters) states that he considers the remains of this fortress to be the most admirable specimen of ancient military architecture he had ever met with in all his extensive travels.

The principal entrance is admirably constructed for defence, with flank walls, from which the assailants were exposed to the attack of the defenders. Some of the walls are of solid masonry, 12 feet in thickness. Others, of that species of construction termed *Emplecton*,† are fifteen feet thick. At two of the angles of the walls are square towers of solid masonry, and there are several remains of fosses, 25 to 30 feet deep, cut in the solid rock, and defending the accessible approaches to the castles. In one part is a subterranean passage, nine feet wide and twelve feet high, leading in an inclined plane from the castle to the fosse, probably for the use of cavalry; and in other parts of the walls are small openings, about two feet in height, and sufficient to allow a man to creep through, by which the sorties were probably made.

The suburb of Epipolæ was terminated by a second almost impregnable fortress, called Euryale, mentioned particularly by Livy in his account of the siege of Syracuse, by Marcellus. In the 17th century the village of Belvedere was built on this spot, but no vestige of it now remains.

The river Anapus, so much vaunted by the poets and historians of old, is now a small stream, and its banks covered with lofty reeds and aquatic plants, growing so luxuriantly as almost to impede our progress in a small boat. We contrived, however, to reach the beautiful fountain of Cyane, a natural basin of about 50 feet in diameter, and celebrated by the poets as the spot where Pluto made his descent with Proserpine. We here saw the elegant Papyrus plant growing in great perfection, and it is said to be the only spot in Europe where this rare plant flourishes.

It has been remarked that there is no ancient example of any state so circumscribed in territory, extending so far and wide its influence, as Syracuse. In military fame she was equal to Lacedæmon, and contested successfully with the Athenians for naval pre-eminence! Her laws excited the admiration of Aristotle. The great Theban bard sung the victories of her conquerors in the games of Greece. From her power emanated the colonies of Acræ, Casmenæ, and Camarina. Her resources were so great, that Gelo offered to assist the Grecian states in their armament against the Persians with 28,000 troops and 200 *Triremes*, and, in addition, to supply provisions for the entire army of Greece, during the continuance of the war; and the perfection she had attained in the fine arts was such as to soften the hitherto rigid habits of her Roman conquerors, to refine their taste, and to excite and ensure their clemency.

Fazello tells us that her skill in works of gold, silver, and embroidery, was proverbial! The extent and magnificence of her buildings we have already adverted to. The superb medallions of Philistides sufficiently testify the superiority she had attained in the numismatic art; and of the extent of her sculptural embellishments we may form some idea from the remark of Cicero, that the Syracusans lost more *statues* by the rapacity of Verres than they did *men* by the *victories* of Marcellus.

The indefatigable Capodieci* presents us with a glorious list of warriors, statesmen, poets, philosophers, and men of science, whom he claims for Syracuse; and proud indeed must that city be which could produce Agathocles and Dionysius as commanders! Philistus as an historian! the poet Theocritus, and, greater by far than all these, her own Archimedes!

I trust this feeble attempt to describe the ancient Syracuse, will be excused, with all its imperfections; and most amply shall I be repaid if the interest of this meeting has been in the least degree promoted by a short account of that city, where the friendship of Damon and Pythias was fostered, and whose inhabitants derived their greatest pleasure in listening to the verses of Euripides!

* One, in the Roman capital, from Macedonia; a second at Pontus; and the third at Syracuse.—Cic. in Ver., 2, lib. iv.

† Plin. Nat. Hist., lib. 36, c. 22.

* The compiler of forty folio volumes on the antiquities of his native city.

INSTITUTION OF MECHANICAL ENGINEERS.

A second meeting of the promoters for establishing a national "Institution of Mechanical Engineers" was held at the Queen's Hotel, Birmingham, on Wednesday evening, the 27th ult., when it was at once resolved to establish the Institution. The meeting was attended by Mr. George Stephenson and about 70 other gentlemen. The object in establishing the Institution was explained by Mr. McConnell. It is to enable mechanics and engineers engaged in the various manufacturing and railway establishments of the country to meet and correspond. The early progress of the Institution having been briefly sketched by Mr. McConnell, and the formal resolutions adopted for conducting it,—

The President elect (Mr. STEPHENSON) addressed the members at some length, adverting to the difficulties he had encountered in his own early career, when, without education, assistance, or apprenticeship, and in the face of a vast amount of prejudice, he had succeeded in battling his way, until success crowned his exertions. He enjoined perseverance as essential to a young engineer, pointed out the folly of attempting impossibilities, for there was, he said, a law which governed mechanics, as everything else; there was a point to which mechanical skill could be carried, and no further. Mr. Stephenson concluded by observing that he should aid this rising Institution by every means in his power. The council, and other officers were afterwards appointed, and a general meeting of the members is to be held quarterly. A dinner afterwards took place; and in the course of some observations during the after *sederunt*, Mr. Stephenson said—"I have worked my way, but I have worked as hard as any man in the world, and I have overcome obstacles which it falls to the lot of but few men to encounter. I have known the day when my son was a child, that after my daily labour was at an end, I have gone home to my single room and cleaned clocks and watches, in order that I might be enabled to put my child to school. I had felt too acutely myself the loss of an education not to be fully sensible of how much advantage one would be to him. I may say, too, perhaps, without being deemed egotistical, that I have mixed with a greater variety of society than, perhaps, any man living. I have dined in mines, for I was once a miner; and I have dined with kings and queens, and with all grades of nobility; and have seen enough to inspire me with the hope that my exertions have not been without their beneficial results—that my labour has not been in vain."

CORDES AND LOCKE'S ROTARY ENGINE.

We have received a copy of a report by Mr. Josiah Parkes on the merits of "Cordes and Locke's condensing rotary steam engine." This engine is a contrivance for gaining power from the momentum or impact of steam, unassisted by its expansive force. The apparatus is so simple, that the nature of it may be readily comprehended without a figure: it consists of a vertical paddle wheel, revolving freely in a cylindrical case, and each float or paddle in succession is exposed to the action of a current of steam rushing against it from a pipe entering the side of the cylindrical case tangentially; so that steam impinges perpendicularly on each float.

The action may be compared to that of an undershot water-wheel, except that the steam does not act on the floats at their lowest position, but when they are about half-way between their highest and lowest position. The cylindrical case opens into a condenser, so that the steam may be said to flow from the boiler through the case into the condenser, meeting the paddles in its course. The extremities of the paddle-wheels do not quite touch the internal cylindrical surface of the case, and the expansive action of steam is in no way employed.

Mr. Parkes makes out that under these circumstances the steam acts with, as nearly as possible, the same efficiency as in an ordinary cylinder condensing engine. He arrives at this result in the following manner:—

"I must first state that this kind of engine precluded the employment of the indicator to ascertain its gross power, as in ordinary cylinder engines; and even if that instrument could have availed for the purpose, it was deemed to be of far greater importance to measure the amount of force actually disposable, as delivered off by the engine, rather than the power of the steam in action, which alone is denoted by the indicator. To attain this end it was necessary to fix upon some sufficiently uniform load to be applied to your engine, as well as upon some method of determining the resistance overcome. The load selected was a screw-propeller, submerged and driven round in a tank of water, 16 feet by 11 feet square. The resistance was weighed by Mr. Davies's dynamometer, adapted to a strap-pulley on a counter-shaft, working intermediate between the engine and screw-shaft.

These preliminary arrangements having been made, the engine was worked during several days; the quantity of water, as steam, which passed through the wheel-case, as well as through the small auxiliary engine which drove the air-pumps, being carefully measured on each occasion. The resistance shown by the dynamometer was continually noted; the number of revolutions made by the wheel was exhibited by a counter; the pressure of the steam as it entered the wheel-case, was observed on a thermometric steam-gauge; the value of the vacuum in the wheel-case was obtained by an ordinary gauge communicating with it; and the amount of power employed to drive the air-pumps and maintain the vacuum, was ascertained by an indicator. The diameter of the steam-wheel in question is 11 feet 7 inches, and at 502 revolutions per minute, its periphery travels at the rate of about 208 miles per hour. The width of the wheel-case is 15 inches; the number of vanes and radial arms 28; the breadth of each vane 6 inches, the depth 7 inches, and the area, therefore, of each vane about 42 square inches. The orifice of the steam-jet is of an oval shape, 3 inches by 2 inches, set vertically.

It appeared, after a great number of trials, that your engine gave the following results, when using steam in the boiler at a pressure of 2¾ lb. per square inch above the atmosphere:

Revolutions of wheel per minute	..	502
Horses power per dynamometer	..	32
Vacuum in the wheel-case ..	..	27·2 in. of mercury.
Water expended per horse power	..	100 lb. per hour.

The same dynamometer and strap-pulley were then transferred to your works at Newport, Monmouthshire, and applied to a condensing engine made by Messrs. Bowman and Galloway, of Manchester, having the following principal dimensions, viz.: diameter of cylinder 30 inches, length of stroke 5 feet. Previously to the experiments, the engine was put into the best possible working condition. My indicator was applied to the cylinder; the dynamometer to the engine-shaft; cards were taken during several hours of continuous work, under an uniform load; the index of the dynamometer was noted down every five minutes; the water consumed, as steam, was accurately measured. The subjoined may fairly be considered to represent the mean result of numerous trials:

Speed of piston per minute	..	220 feet.
Mean pressure per indicator	..	10·342 lb. per square inch.
Mean vacuum throughout stroke		10·186 ,,
Vacuum in condenser ..	..	26·5 in. of mercury.
Water evaporated per hour	..	3248 lb.

The *indicated* power amounted, from the above data, to 48·73 horses; and the water expended for each horse power, per hour, to 66·65 lb.

The *dynamometric*, or effective power, as denoted by the instrument, was 32·29 horses; and the water expended for each effective horse power, per hour, was 100·5 lb.

It hence appears that the power actually delivered off by the cylinder engine, was less than the gross or indicated power by 33·73 per cent.; and, that a similar useful effect was obtained both from the cylinder, and your rotary engine, with the same expenditure of steam and fuel."

Mr. Parkes had some years ago the misfortune to publish, in the third volume of the *Transactions of the Institution of Civil Engineers*, a paper calculating the power of steam engines, in a manner much more amusing than instructive. The reader who is curious in such matters may find in the second edition of the Count de Pambour's Treatise on Locomotive Engines, an ample critique upon this paper, and exposure of its errors. We are not going out of the way in referring to this matter, because we can only conjecture Mr. Parkes' present mode of calculation, by comparison with what he did in 1840. At that time he could not understand that the effect of a steam engine depends directly and absolutely on the evaporation, and that it is utterly impossible to compute the effect without having estimated numerically the quantity of steam generated in a given time. Seven years of subsequent experience have not much mended matters, for the calculations now presented to us are evidently independent of the essential consideration just stated. The "mean pressure per indicator," or cylinder pressure is given, together with the quantity of water evaporated per hour; but nothing is said about the boiler pressure. Now, having given the quantity of *water* evaporated per hour, we must know the boiler pressure, in order to calculate the quantity of *steam* generated per hour; and this being known, we may calculate the velocity of the engine from the work done, or the work done from the velocity. By omitting, however, a single element of this computation, the whole chain of reasoning is broken, and when Mr. Parkes tells us that the "power actually delivered off by the cylinder engine was less than the gross or indicated power by 33·73 per cent." we are entitled to attribute the fault not to the engine but to his calculations.

The principal assertion, that an equal effect was produced from both kinds of engines, with the "same expenditure of steam and fuel," does not anywhere appear to have been corroborated by direct experiment. With respect to the expenditure of steam, we know that that could not have been ascertained, because the boiler pressure is not recorded: and if the expenditure of fuel in the cylinder and the rotary engines had been compared, something would have been said to show that in both cases it was consumed in firegrates of the same form and dimensions; as otherwise the comparison would not be a fair one.

Another altogether different application of the rotary engine was as an *auxiliary* to the common cylinder engine, by causing the steam in its course from the cylinders of the ordinary construction to the condenser to pass through a circular steam case with revolving paddles, as before described. The experiments on the rotary engine so employed were as follows:—

"One of the wheel or rotary engines, divested of its air-pump, condenser, &c., is connected at your works with a common reciprocating condensing engine, in the following manner. The steam wheel is placed near to the cylinder of the condensing engine, in the same room, and is simply acted upon by the steam discharged from the latter. It therefore stands intermediate between the cylinder and the condenser, and derives all the power it gives off from the waste steam of the condensing engine, in its passage from the cylinder to the condenser.

Each engine drives a perfectly distinct load in the manufactory, that is to say, each drives sets of machines perfectly distinct, and in separate buildings; the power of the cylinder engine being given off to a main upright shaft connected with one kind of machinery, and the power of the wheel engine applied to a strap communicating motion to machinery at a distance. This condition of things has existed in actual daily operation at the works for 18 months past. In order to arrive at the separate value of the effect produced by each engine, and of their combined effect, the following methods of proof were adopted.

The usual loads were disengaged, and friction breaks were applied in such manner as to balance the whole power delivered off by each engine. Indicator cards were frequently taken from the cylinder engine; each break was placed under the separate management of an experienced mechanic, with every provision to maintain uniform friction; the water evaporated was measured throughout the experiments. The results were,

Indicated, or gross H.P., of the cylinder engine,	..	22·86.
Effective H P., as per break	..	15·70.
Exhibiting a loss of about 31·32 per cent.		
Effective H.P., from the rotary engine, as per break	..	5·00.
Water evaporated per hour	..	1800 lb.
Giving for indicated H.P., per horse per hour	..	78·74 lb.
Giving for effective H.P., per horse per hour	..	114·65 lb.
Giving for combined effective H.P., per horse per hour,		86·99 lb.

The dimensions of the cylinder engine were:

Diameter of cylinder ..	..	19½ inches.
Length of stroke	..	3 feet.
Speed of piston, per minute	..	263 feet.
Mean pressure per indicator	..	10·1 lb. per sq. in.

The dimensions of the rotary engine were:

Diameter of wheel, 7 feet 9 inches.
Number of vanes, 30.
Size of vane 4½ inches wide, by 5 inches deep.
Two steam jets 2½ inches diameter each.

The useful fact developed by these last experiments, is the recovery of five horses effective power, in addition to 15·7 horses power from the same original steam, that is to say, steam which would otherwise have passed uselessly into the condenser, and been annihilated. It is, therefore, manifest that nearly one-third more power may be obtained from any cylinder engine by combining with it this rotary engine, without the use of additional fuel, boiler, or apparatus of any kind.*

With the view of proving that the auxiliary or supplemental wheel engine, as combined with the condensing engine, did not diminish the performance of the latter, the indicator and break were applied to it when working alone, the connexion with the wheel engine having been shut off, and the waste steam suffered to pass through its usual pipe to the condenser. Under these circumstances the effective power of the Condensing Engine came out 15·637 horses, and the water expended as steam 115·1 lb. per horse per hour; thus demonstrating that no diminution of its original power, nor increased consumption, were occasion by its combination with the Rotary Engine.

In order to prove that no opposition to the passage of the waste steam from the cylinder to the condenser is occasioned by the interposed wheel and case, the indicator was applied on the connecting pipe immediately in front of the jet holes, and the vacuum exhibited by it was in close accordance with the vacuum in the cylinder as ascertained by the same instrument. The wheel-case is, in fact, a virtual enlargement of the condenser, and the value of the vacuum in the cylinder suffers no depreciation from its interposition. The power recovered and given off by the wheel is simply due to the steam's momentum—low as is its elastic force—acting by impact on the wheel vanes *in transitu* between the cylinder and condenser;—the wheel working *in vacuo*, and therefore, unresisted, or resisted only to the extent of imperfection of such vacuum. The more perfect the vacuum maintained throughout the case, the greater will be the useful effect obtained from the wheel.

In respect of the practical economy of your rotary engine, as regards steam and fuel, and as compared with the ordinary unexpansive cylinder engines, we know that the latter are not worked with less than 70 lb. of water per horse per hour, and they much oftener reach or exceed 80 lb., deduction being made of friction only when the engine is unloaded, which is very small. It appears, however, from the foregoing dynamometric and break experiments, that fully 30 per cent. should be deducted from the gross indicated power of the cylinder engine, as the value of its friction when loaded; or, in other words, that we realise less than 70 per cent. of the gross power; and the loss of effect when speed has to be quickly got up, as in the case of marine engines working screw propellers, most probably considerably exceeds 30 per cent. The consumption, therefore, of 100 lb. of water as steam per horse power, per hour, by your engine, may be considered, in respect of economy, as placing it on an equally advantageous footing with the class of engines alluded to."

The errors of calculation here exhibited appear to be just the same as before, and destroy all confidence in the results. The question of the expediency of employing the revolving steam-wheel resolves itself simply into this—is more power gained from the impinging force of the steam than is lost by obstructing its passage from the cylinder to the condenser? The assertion that *no* force is lost by thus impeding the passage of the steam is manifestly absurd; for it is equivalent to saying that the efficiency of the condenser is just the same, whether the steam-ways be large or small. Mr. Parkes alleges, in proof of his assertion, a circumstance which does not bear on the case in the slightest degree. Premising that the power of the condensing engine in both cases "*came out*" nearly the same (by his calculations), he adds, when the rotary engine was at work, the vacuum in the cylinder and condenser was nearly the same. But the obvious way of testing his assertion was to try whether the vacuum in the cylinder was the same when the rotary engine was connected, and when it was disconnected—that is, to ascertain whether the resistance to the motion of the piston from imperfect condensation was not increased by the interposition of the steam-wheel.

We by no means take on ourselves to decide absolutely against the merits of Messrs. Cordes and Locke's invention. On the contrary, so little is known of the impinging force of steam that the question is still fairly arguable whether more be not gained by employing that force than is lost by obstructing the passage to the condenser. The circumstance stated in the foot-note, of 100 tons of coal being saved in 18 months, seems of itself an unmistakable fact—a *voie de fait*, as the French call it—in favour of the invention. At all events, the inventors deserve the credit of calling attention to a very interesting subject, and it may be hoped that for the sake of science they will continue their investigation. The foregoing remarks refer exclusively to the erroneous methods of calculation adopted in the report sent by them, and will, we hope, direct—not repress—their efforts.

* By reference to the coal account, during the last eighteen months, I find that a saving of 100 tons of coals has been effected within that period, by working the wheel in connection with the cylinder engine, whilst the power recovered from the cylinder engine has been more than equal to the duty performed by a separate engine, previously employed for that purpose only. And I also understand that the Rotary has not cost 5s. in repairs during that time; that the packing, in the stuffing boxes of the wheel-axle, has been but once renewed; and that nothing has occurred to require the case to be opened. —J. P.

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*Values of Gages for Wire and Sheet Metals in general use, expressed in decimal parts of the inch.**

SECTION ONE. Birmingham Gage for Iron Wire, and for Sheet Iron and Steel.		SECTION TWO. Birmingham Gage for Sheet Metals, Brass, Gold, Silver, &c.		SECTION THREE. Lancashire Gage for round Steel Wire, and also for Pinion Wire. The smaller sizes distinguished by Numbers. The larger by Letters, and called the Letter Gage.					
MARK.	SIZE.	MARK.	SIZE.	MARK.	SIZE.	MARK.	SIZE	MARK.	SIZE.
0000	·454	1	·004	80	·013	40	·096	A	·234
000	·425	2	·005	79	·014	39	·098	B	·238
00	·380	3	·008	78	·015	38	·100	C	·242
0	·340	4	·010	77	·016	37	·102	D	·246
1	·300	5	·012	76	·018	36	·105	E	·250
2	·284	6	·013	75	·019	35	·107	F	·257
3	·259	7	·015	74	·022	34	·109	G	·261
4	·238	8	·016	73	·023	33	·111	H	·266
5	·220	9	·019	72	·024	32	·115	I	·272
6	·203	10	·024	71	·026	31	·118	J	·277
7	·180	11	·029	70	·027	30	·125	K	·281
8	·165	12	·034	69	·029	29	·134	L	·290
9	·148	13	·036	68	·030	28	·138	M	·295
10	·134	14	·041	67	·031	27	·141	N	·302
11	·120	15	·047	66	·032	26	·143	O	·316
12	·109	16	·051	65	·033	25	·146	P	·323
13	·095	17	·057	64	·034	24	·148	Q	·332
14	·083	18	·061	63	·035	23	·150	R	·339
15	·072	19	·064	62	·036	22	·152	S	·348
16	·065	20	·067	61	·038	21	·157	T	·358
17	·058	21	·072	60	·039	20	·160	U	·368
18	·049	22	·074	59	·040	19	·164	V	·377
19	·042	23	·077	58	·041	18	·167	W	·386
20	·035	24	·082	57	·042	17	·169	X	·397
21	·032	25	·095	56	·044	16	·174	Y	·404
22	·028	26	·103	55	·050	15	·175	Z	·413
23	·025	27	·113	54	·055	14	·177	A 1	·420
24	·022	28	·120	53	·058	13	·180	B 1	·431
25	·020	29	·124	52	·060	12	·185	C 1	·443
26	·018	30	·126	51	·064	11	·189	D 1	·452
27	·016	31	·133	50	·067	10	·190	E 1	·462
28	·014	32	·143	49	·070	9	·191	F 1	·475
29	·013	33	·145	48	·073	8	·192	G 1	·484
30	·012	34	·148	47	·076	7	·195	H 1	·494
31	·010	35	·158	46	·078	6	·198		
32	·009	36	·167	45	·080	5	·201		
33	·008			44	·084	4	·204		
34	·007			43	·086	3	·209		
35	·005			42	·091	2	·219		
36	·004			41	·095	1	·227		

* From a pamphlet on Decimal Gauges, by Mr. Holtzapffel.

NEW METROPOLITAN CHURCHES.

In almost every part of England new churches are being built, of which the architecture would be worthy of the best days of ancient ecclesiastical art. Those who love architecture for its own sake, and who, in order to see noble specimens of it, are willing to make short pilgrimages (no great labour in these railway times), may see, in every county, modern churches, the monuments of private munificence, which elicit the admiration of the strictest and most determined disciple of ancient art. The recent edifices, if they do not always possess the *massive* simplicity and unity which remains hitherto a characteristic of the olden time, still exhibit in their details a magnificence and propriety which we can hardly hope to see excelled.

In London, however, it is not so. Here, churches are built to cover in a given number of square feet of ground, and the architect must so arrange the building, that the greatest possible number of sittings may be contained within it. *It does not pay* to build London churches with thick solid walls and massive piers and buttresses—the pew-rents would not cover the outlay. Plaster and patent cement and deal boards keep out the weather (while they last) nearly as well as stone and oak, and, if properly coloured, look as well. To be sure, these lath-and-plaster edifices will not last for quite so many centuries as the mediæval piles which they mimic (one of these fragile fabrics has already began to fall, almost before its completion)—but, then, those who build these churches have no concern in the permanence of them for centuries—for to themselves the pew-rents cannot accrue beyond the term of their natural lives. They have made the churches to be houses of merchandise, and they build them just strong enough to answer the intended purpose. Our ancestors did not build in such a manner, nor with such objects. Do we wrong to commend the old custom, as a *good* old custom?

We are not "travelling out of the record" in making these observations: they have more connection with architecture than may appear at first sight. In many even of the best of modern churches—though the critic can detect no fault of design or detail—*something* is felt to be wanting which renders these buildings less impressive than their ancient prototypes. The detection of this *something* is oftentimes very puzzling—the construction of the building is faithfully expressed by the decoration, the materials are honest and real, the composition simple and connected, and the mouldings, tracery, &c. graceful, and appropriate to the style adopted—and yet the eye is not satisfied. The more this anomaly is considered (and we doubt not that it has occurred to many careful observers), the more readily will it be referred to the comparative slightness of building adopted in modern structures. This explanation may perhaps be objected to as too material. It may be thought a very matter-of-fact kind of criticism which measures the thickness of walls and the sectional area of buttresses; but it is precisely this kind of criticism which, if it be correct, is the most useful, because it is the most easy of application.

It is by no means to be inferred that we would commend heavy clumsy modes of construction, when our present increased knowledge of mechanics has revealed improved and more scientific methods. The worst sort of affectation is that which apes inferiority. But we do want to see churches built as if they were meant to last—not as if the architect had been accustomed all his life to "run up" cockney villas or new metropolitan streets—as if he had no idea of magnificence beyond the plaster glories of the Regent's Park or Belgravia. How willingly does the eye, wearied of this showy, ephemeral finery, turn to the ancient, unpretending, village church, with its vast bold buttresses and massive tower! Those venerable walls tell their story so simply, and yet so well—that within them successive generations of men have assembled in piety and reverence for, it may be, these six or seven centuries past. It is not merely that we admire the village church for its own intrinsic beauty, but that we feel that it was built for ages. It is the type of permanence, as far as the work of men's hands can be so. The ancient churchmen, it has been well said, built "for religion, not for fame; for endurance, not by contract; for devotion, not in a spirit of economy; *pro salute animæ, non pro crumenâ.*"

Old Street Road.—A new church has been recently built here by Mr. Ferrey, in the Early English style. The nave and aisles are under separate gables, and the entrance is under the tower, which is at the south-west angle. Externally, the masonry is of rag, with Caen stone dressings, which have (as in many other modern churches) a most unsatisfactory, "patchy" appearance. It is well enough to use Caen or similar stone for the mouldings or tracery of a church, for rag cannot be worked for the purpose; but there is now a mania for sticking all over a church bits of the former kind of stone; and its light colour, contrasted with the dark hue of the coarser material, gives the building an appearance of stone patchwork, or the fantastic pattern of a harlequin's dress. Besides, it is ridiculous to use the *weaker* stone for quoins and angles, where, if any difference be made, it should be in favour of the material which had the greatest cohesive force. Had the angles of the buttresses, &c. of Mr. Ferrey's church been of rag-stone like the rest, the effect would have been much better. The love of finery in architecture has grown into a habit which seems almost inveterate.

The windows on the south are arcades of four arches, two blank and two pierced for light—this arrangement, defended though it be by precedent, is most unworthy of modern imitation. Blank windows are equally inartistic, whether they occur in Classic or Pointed architecture. In the present case, the masses of Caen stone in the blank arches exaggerate the patchwork effect of which we have complained, to an unusual degree. The windows on the north side are couplets. This side of the building is much the best. The south side is next the street, and is of course made the most showy—for that very reason, it is inferior in appearance to the other. The rose window at the east end is much too large. We have not had an opportunity of seeing the interior of the building.

Hoxton.—Another Early English church is nearly finished here, which is a specimen of "Modern Gothic," of more than ordinary hideousness. It scarcely deserves a detailed notice. It is sufficient to say that it exhibits all the following characteristics of its tribe in an eminent manner—miserably thin walls, with square reveals to the windows, as in an ordinary dwelling house—poor tracery—cast iron girders—pinnacles ugly enough to have been built twenty years ago—plenty of plaster and stucco, and an enormous disproportionate chancel-arch, with a small communion recess beyond it.

RAILWAY STATISTICS.

From the *Eisenbahn-Jahrbuch* (Railway Year-book), recently published by the Baron de Reden at Berlin, we obtain some valuable additions to railway statistics. The author is now in office under the Prussian government, and formerly superintended the construction of the railway from Berlin to Stettin.

The analysis of accidents which occurred on railways in Belgium, England, France, and Germany, respectively, during five years, commencing 1st August, 1840, is as follows:—

	Fatal Accidents.	Total number of Accidents.
Belgium	35	100
England	300	1500
France	71	220
Germany	11	22

It appears, from this table, that the total number of persons in any way injured during this period, in the four countries, was 1,842; and of these accidents, 417, or between one-fourth and one-fifth, were fatal. The following table shows approximately what proportion of these accidents have occurred in each country, and also the annual average of accidents:—

	Fatal accidents annually.	Total accidents annually.
Belgium	7 or $\frac{1}{14}$th	20 or $\frac{1}{5}$th
England	60 or $\frac{2}{3}$ths	300 or $\frac{6}{7}$ths
France	14·2 or $\frac{1}{5}$th	44 or $\frac{1}{3}$th
Germany	2·2 or $\frac{1}{5}$th	4·4 or $\frac{1}{2}$th

In this table, the casualties on French lines include those of the Versailles catastrophe, by which 55 lives were lost. The accidents on the Belgian lines in 1843 and 1844 arose almost entirely from breakage of axles and from carriages getting off the rails.

A more accurate estimate of the relative insecurity of railways in either country is obtained by comparing the number of casualties with the total number of passengers conveyed. Taking the annual mean proportion, we get the following results, which distinguish whether the accident arose from the fault of the sufferers or of the railway managers:—

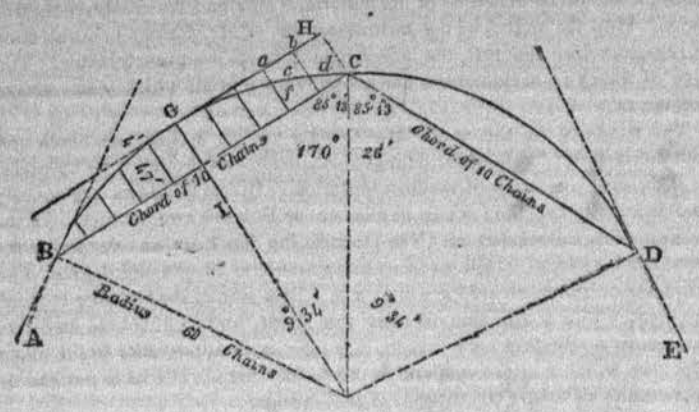
	Passengers killed from their own neglect.	Officials killed and wounded from their own neglect.	Persons killed from defective managemt.
Belgium	1 in 670,000	1 in 280,000	1 in 1,690,764
England	1 in 869,000	1 in 300,000	1 in 852,416
France	1 in 2,157,000	1 in 5,000,000	1 in 3,465,996
Germany	1 in 25,000,000	1 in 9,000,000	1 in 12,252,858

In this list, each country is placed in the order of the relative insecurity of its railways. The terrible disproportion in this respect, between the two former and the two latter, is very significant and deserves careful attention.

SETTING OUT RAILWAY CURVES.

SIR—The following mode of setting out curves, by means of equal chords and ordinates, which I have successfully practised, is both accurate and easy of being applied :—

Fig. 1.



Let B and D be the ends of two straight lines, tangents to the curve B C D, which we wish to set out—the position of the two lines having been correctly determined from the base line of the survey. We must then ascertain the angle that a chord of any convenient length (say 10 chains) makes with the tangent A B; which having found, the intermediate points on the curve are fixed by offsets from the chord. The radius being known, and the length of the chord determined, the following formula will enable us to find the angles of chord and tangent :

$$\text{Radius} : \tfrac{1}{2}\text{ chord} :: 1 : \sin \tfrac{1}{2}\text{ the arc.}$$

$$\text{Therefore, } \sin \tfrac{1}{2}\text{ the arc} = \frac{\text{chord.}}{2\text{ radius.}}$$

Thus, if chord = 10 chains, and radius = 60 chains,

$$\sin \tfrac{1}{2}\text{ arc} = \tfrac{10}{120} = \tfrac{1}{12} = \cdot 0833' = \text{nat sine } 4^\circ\ 47'.$$

To find the offsets, the line F G which bisects the chord is at right angles with it. G H, which is a tangent to the curve, is also at right angles with F G. G H and I C are, therefore, parallel. If H C be drawn at right angles with I G, it will be parallel to I G, and also equal to it; and G H = T C = 5 chains.

$$H C = F G - \sqrt{F G^2 - G H^2}$$

$$b d = F G - \sqrt{F G^2 - G b^2}\text{; and}$$

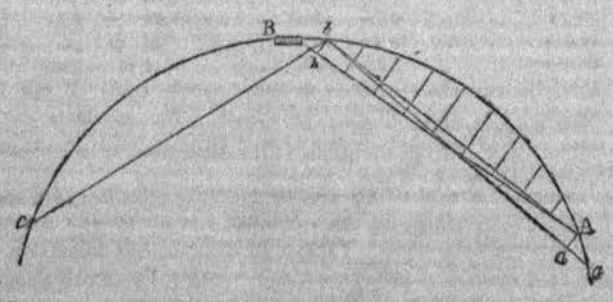
$$a c = F G - \sqrt{F G^2 - G a^2}.$$

The parallel lines, H C, $b f$, $a e$, and G I, are all equal.

Therefore, $d f = H C - b d$; $c e = H C - a c$, &c.; and G I = H C.

The formula $\frac{G H^2}{2 F G}$ will give a very near approximation to the distance of the tangent from the curve, and might be taken as the offset without producing any appreciable error; $\frac{G b^2}{2 F G}$ will give $b d$; and $\frac{G a^2}{2 F G} = a c$, &c.

Fig. 2.



In the case where a building or other obstacle may intervene, at B, (fig. 2) to prevent the setting up of a theodolite; if from A we set off the distance A a' equal to $b b'$, we shall have the direction of a chord, $b a$, of 10 chains; by means of which we can determine the direction of a new chord, $b c$.

Carmarthen, Jan. 3, 1847. Z.

SIR—I had no intention to excite the ire of your correspondent, "An Engineer out of Employment." He has evidently mistaken my meaning. I shall leave him, therefore, to cool on it.

A specific chord line, it is well known, presupposes two points, already determined in a curve. The first, or starting point, can be attended with no difficulty; but the other, though easily found, or assumed, on paper, is not always so readily found *on the ground*: and when obtained. or given, on the ground, it must be SEEN from the other point in order to be of any use. "To find it out," as your correspondent says, "by the aid of a common theodolite," would be an endless affair—even if the surveyor knew how to set about it. The time occupied in his doing so might certainly be employed to more advantge, I may say, by *any other* mode of tracing a curve—even by "building," as your correspondent calls it! —*apropos*, my instrument does not, by any means, limit the length of the tangent: it may be either lengthened or shortened, according to local or other circumstances.

Military Library, 30, Charing-cross. W. TAIT.

SAFETY OF RAILWAYS.

(Extract from a Report made to the Minister of Public Works in France, by M. DE BOUREUILLE, head of the Railway Department.) Translated for the 'London Journal.'

The Special Commission, charged by the Minister of Public Works to inquire into the questions relating to the security of transit upon railways, has, from the first, had two subjects of very different natures to consider. The catastrophe of the 8th May, 1842, had called public attention most particularly to the construction of axles of locomotive engines and carriages, and to the terrible consequences of the shocks to which passenger trains might be exposed upon railways.

The safety of railway transit may depend on various circumstances; 1st,—On the state of the road or way, and the mode of its construction; 2ndly,—On the state of the materials employed, viz., the engines and carriages, and the different parts of which they are composed, viz., the wheels, axles, springs, &c.; 3rdly,—On the formation of the trains—that is to say, the mode of attaching the engines and carriages together, the kind of brake employed, the methods of deadening shocks, &c.; 4thly,—On the regulations to be observed when the trains are running, the speed at which they are to travel, the signals and means of communication established either between the engine-drivers, or between them and the officials at the stations or on the road; 5thly and lastly,—On the degree of intelligence employed in the service, and the ability and characters of the persons employed.

1. *On the Railway and its Accessaries, such as Crossings and Changes in the direction of the Road.*

It will be unnecessary here to recapitulate the various plans which have been successively employed for the construction of railways: it will be sufficient to observe that the method now generally adopted in France consists in fixing the rails by means of wooden chairs placed in cast iron bearings, which are fixed two together upon wooden sleepers, placed at equal distances apart: the number of sleepers varies according to the nature of the soil upon which the road is to be formed, the weight of the rails, &c. The sleepers are covered with sand to keep them in their proper position.

Some engineers, in order to render the rails more firm, and to prevent their bending between the transverse sleepers, have proposed to lay the rails upon longitudinal sleepers. The line of rail from London to Bristol is laid down in this manner; but it is not apparent that this plan has been much followed in France.

The Commission had therefore to inquire, on the one hand, whether this method of constructing railways was sufficient to maintain the rails at the required distance. This was answered affirmatively, adding, however, that it would be advisable to place the sleepers nearer together at the junction of two lines of rail, than at the intermediate points. As a corollary to this question, the Commission inquired whether the breadth between the rails most commonly adopted, viz., 4 ft. 8 in., was sufficient, and whether it would not be advisable to increase it. On the first point, the answer in the affirmative was given without hesitation; and, as to the width of road, the Commission was of opinion, that the gauge at present in use might be continued; adding, however, that it would be advisable to keep it in tunnels, and between the parapets of works, the same as on levels and in cuttings.

With regard to any alterations to be made in the position and form of the road, the Commission declares, that the depression or elevation of the rails, a defect in fixing them in the chairs, derangement of the sleepers supporting them, inequality in the sand forming the foundation of the road, or too thin a layer of this sand, must be considered as very likely causes for the carriages getting off the rails. The Commission mentions two other causes of the rails getting out of order, which seem to be quite as dangerous :—First, the displacement of the rails in a longitudinal direction, or direction of movement; and secondly, the uniform inclination of the sleepers supporting the chairs and the consequent displacement of the rails. These various causes of danger may be averted, or at least greatly modified, by a constant and attentive surveillance of the road.

The Commission had still to examine, on the one hand, whether the form adopted for the rails was the most suitable; and on the other hand, whether the test of the manufacture of the rails, before employing them, was sufficient to be relied upon.

There are three different systems of switches employed upon railways; the first—that of moveable rails, which act by pressing upon the inside of the carriage wheels, so as to force them to run in the required direction. This plan possesses the disadvantage of loosening the wheels and wearing them away quickly. The second system is, that of the moveable rails, which may, by turning on a pivot, be moved in the direction in which the train is required to run. In this plan, there is no pressure on the inside of the wheels; but, if by chance, the moveable rail is badly placed, the engine will run off the rails. And, lastly, the third plan, which is generally adopted at present, is one that unites the advantages of the first two. It is composed of double switches, arranged in such a manner that there may be always a moveable rail opposite each road; and the switches being always brought back to their original position, by a counterbalance weight, there is no danger of running off the rails. This latter plan is much preferable, as regards public safety.

Independently of the changes and crossings in a level, the Commission has given its attention to some questions which are of great importance as regards security in travelling. For instance, when a railroad is carried across a deep valley, which can only be traversed by means of lofty viaducts, or through deep cuttings, or across rivers, of greater or less width, it will be understood that it would be much more dangerous to run off the rails at such places than when travelling on a level road, although attended at all times with much danger. In order to prevent this, as much as possible, counter-rails are generally employed, placed either inside or outside the line of rails, and more or less elevated above the ground. The Commission has thought, that in certain cases, the counter-rails may be useful, adding besides, that when used, it is advisable to place them inside the ordinary rails. In fact, by this means, the height of the flange of the wheels is gained; and, besides, if an axle were to break, the wheel, instead of being dragged outside the rails, would have a tendency to run inside, which is an evident advantage as regards safety.

Lastly,—the Commission has had to examine whether, as regards safety of transit, there should not be a limit to the radius of the curves, and what this limit should be; but it was not long in perceiving that nothing positive could be decided on this point, and that it should be left to the government to determine, in each particular case, the limit to be adopted. This limit, as at present stated in the railway books, appears suitable and sufficient for preventing accidents.

II. *On the influence of the state of the materials, as regards safety of transit, and the precautions to be taken for that purpose.*

If the state of the rails, and the materials of which the railway is composed, have great influence upon the security of railway transit, the machinery employed in working it, viz.—the locomotive engines and carriages, is also worthy of serious attention.

Experience has proved, that by forming the upper surface of the rails of a slightly convex form, the oscillation may be much diminished, and the friction of the flanges of the wheels upon the rails will be reduced in proportion. They are, in fact, scarcely in contact, and consequently, the rails may be made about a third of an inch wider, which greatly facilitates the progress upon curves. These slight improvements need not increase the expense of the railway, but by their adoption the chances of accidents will be greatly diminished.

The next question to be discussed relates to the axles. This subject is one that has greatly occupied public attention, from most of the serious railway accidents having been accompanied, if not caused, by the breaking of an axle. The Commission has examined the axle, successively, in all possible positions:—first, in the process of manufacture, and in their form and adjustment; and, afterwards, in the different kinds of work to which they might be adapted. As regards the manufacture of axles, the Commission is of opinion, that this manufacture is now conducted on as perfect a plan as possible, as well for straight as cranked axles. The former are wrought by the hammer; and the cranked axles, which are always larger, are also made of fagotted iron; but in order to give them the desired form, only one method appears to have been thought worthy of being employed. This method consists in putting a number of iron bars together to form a parcel of about two feet square; and these, having been heated in a reverberatory furnace, are submitted to the action of a powerful hammer, and beaten on all sides, in order to weld the bars together: the bar thus made, is afterwards reduced to a thickness somewhat more than the diameter of the intended axle, keeping a sufficient width for the cranked part. Those parts of the axle which are to receive the wheels, are first wrought into the required form, and then the cranks (which do not require to be rounded) are brought to their proper shape.

The form to be given to the axles is not material. It has been proved by experience that axles nearly always break inside the wheels, and at or near the nave. It is therefore advisable to make this part much thicker than the others; and this is generally done by manufacturers; but they do not always pay great attention to the levelling of these parts with the body of the axle, as the incline is generally too abrupt. This mode of manufacture being very defective, and likely to decrease the strength of the axle, it is indispensably necessary to make the thick parts taper gradually down to the smaller ones, or in the form of a truncated cone, the apex of which would be equal to the diameter of the body of the axle.

The Commission had to inquire whether it was advisable, before employing the axles, to test their strength; and their opinion was, that this trial was not desirable, but that there might be certain modes of trial which would not injure the metal, and which would nevertheless expose the defects: such, for instance, as re-heating to a cherry red—an examination of the portions detached from the ends of the axles, &c.

In a word, the especial attention of the Companies should be called to this question, the importance of which may be easily understood; and they ought to be also obliged to keep registers, in which all the axles received should be carefully noted, together with all the circumstances of their reception, and a statement of the proofs to which they had been submitted.

When working on railways, the axles are subjected to strains of different kinds, and to shocks and vibrations, sometimes of a very violent nature, which may cause them to break. Accidents of this nature have frequently happened upon railways; but, in most instances, the circumstances have not been truly investigated, nor the appearance of the fracture considered; except in some cases (fortunately very few) in which the breaking of the axles occasioned serious injury or death. But in these cases, the two broken portions of the axle had been so twisted, that no conclusion could be arrived at from the appearance of the fracture. It is, besides, generally impossible to determine whether the breaking of the axle was the cause of the accident, or merely the effect.

From these circumstances, the Commission has been unable to discover any documents of a nature sufficiently conclusive to determine the probable time that axles would last; but it has no hesitation in declaring that they are deteriorated in quality by use. It may be concluded, from isolated but well-verified facts, that, after a certain time, depending upon the effective work accomplished by each, the axles will break.—Is this owing to any molecular change in the material? It is impossible to determine this from what we know at present; but it will be readily conceived that this is matter of serious consideration, and, consequently, the Commission thinks that every Company ought to be obliged to keep a register, in which should be entered, independently of the particulars of the time of receiving the axles, &c., the number of miles run over by each.

The documents extracted from these registers would doubtless be of great utility for solving the important questions relative to the duration of axles; but the fact cannot be denied that this will furnish no result until after a number of years; and, therefore, the Commission is of opinion that it would be advisable to make some experiments as to the means of ascertaining, at any time, the amount of alteration which has taken place in the axles; and either to restore them to their former state, or limit the period of their working.

After ascertaining the average weight which axles have to support, and the strain they undergo, the following experiments were proposed to be made:—On analysing the strain upon axles, it was found to consist, 1st,—Of a vertical strain, due either to that portion of the weight of the engine bearing upon that point, in consequence of the position of the centre of gravity, or to the action of the springs of the hinder axle in the six-wheel engines. This strain being thus defined, even supposing that the parts upon which it acts are as near as possible to the *point d'appui* formed by the wheels, tends, nevertheless, to bend the axle in a vertical direction.

2nd.—A twist or strain, arising from the conoidal form of the peripheries of the wheels, and inequality in the inclination of the rails; from which it happens that the peripheries of two wheels, fixed upon one axle, never touch the rails at the same part at the same time, and consequently, each of the wheels slip alternately on the rail: if the twist resulting therefrom is not too violent, it keeps all the molecules in a permanent state of vibration.

3rd.—The shocks arising from inequalities in the road, caused by the undulations of the rails, and the momentary depression of the rails at their point of junction when a train passes. These shocks increase in violence in proportion to the speed of the train, and act in a direction at right angles to the axis of the axle.

4th.—Another kind of shock, arising from the oscillation of the train, which acts on the axles both in the direction of their length and at right angles thereto, increasing in force in proportion to the diameter of the wheels on the axles.

In order to appreciate the effects of these four kinds of strain, the Commission is of opinion, that the first series of experiments to be undertaken, should be to inspect a certain number of axles which have already worked for a given time upon railways, and minutely examine their interior texture. As, however, these experiments could not lead to perfectly satisfactory conclusions, from the want of points of comparison, the Commission is of opinion that it would be advisable, at the same time, to commence experiments upon axles.

These experiments might be made by taking an ordinary locomotive axle, furnished with the two wheels, loading it as it would be if adapted to an engine, and giving to it a rotary movement, similar to that which it would acquire if employed upon a railway. By placing the wheels of this axle upon a frame, consisting of another axle, furnished with wheels, to which motion is communicated by a steam engine, the first class of action to be observed will be obtained.

All the other motions might be obtained by this means; and also, by a suitable construction of the wheels of the frame, the twisting of the axles, the shocks arising from the bending of the rails, and the shocks arising from the oscillation. By this method of proceeding, the axle submitted to experiment will be exposed as nearly as possible to the same injurious action as when in use; only, instead of advancing upon a railway, the railway will present itself to the wheels. The Commission, wishing to ascertain the expense of the above experiments, arrived at the following results:—

It will be understood, that the apparatus used for trying the experiments must be made of pretty large proportions, and all the parts must be sufficiently strong to resist the action, the effects of which it is intended to prove.

The details of this apparatus must be carefully attended to; but the expense cannot be estimated at less than from 400*l.* to 500*l.* In order that the experiments may lead to results worthy of interest, it will be necessary to try, comparatively, axles of at least three different diameters, and to act upon two axles of each kind, in all six axles, furnished with their wheels, the expense of which will be about 90*l.*

Lastly.—The working of the apparatus will require a certain amount of power, constant attention, and the renewal or repair of some parts of the mechanism, such as the brass bearings for the axles, or the tyres of the wheels.

In conclusion, the Commission is of opinion that, in order to make experiments in a suitable manner, an outlay of at least 800*l.* will be required. It is evident that these experiments will occupy a considerable time; but this does not appear to be a sufficient reason for abandoning them.

It was observed by the Commission, that in locomotive engines there were many parts subjected to considerable strain and violence, the rupture of which would be of minor importance, and that they might therefore, without much inconvenience, be allowed to remain in use until nearly worn out: of this kind are the rods which connect the locomotive to the tender, and also the bolts which serve to fasten them. By manufacturing several similar pieces with care, putting some of them in use, and keeping the others for the purpose of comparison, the Commission is of opinion that interesting results might soon be arrived at.

To conclude, as regards axles,—it only remained for the Commission to inquire into the precautions to be taken in the case of breakage of axles, in order to prevent any accidents arising therefrom. Plans have been proposed for this purpose by a great number of inventors, which it may be as well to make mention of here.

These plans may be divided into two categories; the first of which consists in the employment of wheels running on the rails in front of the engine, and serving as guides. The second consists in the employment of guides on the rails, the rods of which, being attached to the framing of the engine, are intended to keep the train in its place on the rails. Neither of these plans appeared to the Commission susceptible of useful employment. The guide-wheels would have the inconvenience of preventing the engineer from perceiving the breaking of the axle in time to stop the train.

With regard to the guides, if they were made as proposed, in the form of drags, they would cause shocks and serious accidents; they also would not offer any resistance to the oscillations of the engine; if made light, they would readily be broken when subjected to a violent shock; and if heavy, they would evidently facilitate the running of the train off the rails.

As regards the working of railways, another not less important question occupied the attention of the Commission. On the occasion of the Versailles accident the general opinion was, that nothing fatal would have happened if the locomotive "Matthew Murray" had been mounted on six wheels instead of four. This appeared also to be the opinion of Government, as one of the first precautionary measures was to prohibit the companies in the environs of Paris from making use of locomotive engines with four wheels. Before, however, this measure was made general (the immediate application of which would prove ruinous to many other companies besides those in the environs of Paris), the Commission thought proper to inquire into it as regards safety, and for this purpose took an account of the number of accidents which had happened upon railways worked with locomotives, either of six or four wheels, and the conclusion they came to was that, as regards public safety, the six-wheeled engine possessed some advantage over the four-wheeled engine, especially when the two driving-wheels are provided with flanges; this advantage is not, however, so great at present as entirely to do away with the four-wheeled engines. The attention of engineers must be especially directed to the improvement of the six-wheeled engines, and there is no doubt that when these engines have undergone the improvements which may be suggested, they will be generally preferred.

The parties in favour of the four-wheeled engines brought forward, in support of their opinion, the fact that, in six-wheeled engines, the centre of gravity of the whole was always before the cranked axle, and that, therefore, in case of the front axle breaking, these engines would fall as easily as the four-wheeled engines. On the other hand, by placing the framing which supports the four-wheeled engines inside, the fall of the wheels is prevented when an axle breaks, and there is no further fear of accident; but the Commission observes, that if in most of the present six-wheeled engines the centre of gravity is in front of the cranked axle, there is no practical impossibility in bringing it upon the axle itself. The front axles are, besides, not the only ones the rupture of which is to be feared; the cranked axles frequently break, and such accidents, which are not much to be feared in a six-wheeled engine, may have serious consequences in a four-wheeled.

With regard to the advantage attributed to placing the framing inside, it is, perhaps, sufficient to observe, that this arrangement does not apply particularly to four-wheeled engines, and that nothing conclusive can be arrived at as regards the safety of the engines fitted up in this manner. It does not appear certain that this will prevent the running off from the rails on the breaking of an axle.

Fires can only arise from two causes:—1st. The sparks escaping from the chimney of the locomotive: 2nd. Portions of incandescent or ignited fuel falling from the furnace, which falling pieces, even should there be no wind, are driven along by the current of air produced by the rapid movement of the train.

As regards the sparks which issue from the chimney, the Commission observes, that since railways were first worked, the chimneys of locomotives have always been furnished with a woven wire guard, which stops the sparks, and at the same time returns into the smoke-box a portion of the pulverulent substances, which, when allowed to escape, cause great inconvenience to travellers. This guard has since been somewhat improved; for instance, it has been formed of a closer fabric; also the chimney has been formed trumpet-mouthed, with iron wires stretched across it, whereby a stronger guard than the ordinary one is formed. The employment of the guard not having, however, always produced satisfactory results, other methods have been resorted to, which it will perhaps be advisable here briefly to describe:—

A strong metallic basket was placed at the lower part of the chimney, in the form of a truncated cone with its small end downwards. By this arrangement the portions of cinder and ignited fuel are presented obliquely to the meshes of the fabric, and therefore the smoke will have great difficulty in drawing them up. A horizontal cover was placed in a part of the chimney to arrest the portions of cinder and fuel, and throw them back to the bottom of the chimney, and the smoke escaped by lateral openings. In some cases, these two plans have been combined in one chimney, one above the other. Lastly.—A plate of iron pierced with round holes, about one-third of an inch in diameter, was placed in the smoke-box, in a horizontal position; whereby all the solid portions of fuel, which were not presented directly to the orifices, were immediately thrown back to the bottom of the smoke-box.

To these may be added another method tried in Germany, which appeared to produce satisfactory results. It consists in placing a fan, or wheel furnished with wings, on the top of the chimey, at an inclination of 45°, which, being put in motion by the heated air issuing from the chimney, drives the sparks to the sides of the chimney, where they are extinguished and fall back.

The Commission having ascertained the advantages of these several plans, was of opinion that there was no occasion to recommend any one of them in particular, but that it would be advisable to submit each to regular experiment; and until it should be shown by experience which was the best, the railway companies should be obliged to use one of them.

With regard to the ignited fuel falling from the furnaces of locomotives, the only means known of preventing the accidents which may result therefrom, is by employing an ash-pan to catch the cinders, and thereby prevent them from falling to the ground. There are, however, several disadvantages attending their use, such as—preventing the draft; being too near the ground; causing the bars of the furnace to wear away more quickly, and rendering the cleaning of the furnace more difficult; and, lastly, preventing the engineer from immediately putting out his fire, should it be necessary to do so.

An arrangement might, however, be contrived to do away with these disadvantages, either wholly or partially, in which case the ash-pans might be employed with great advantage; but in the present state of things, the Commission is of opinion that there is no occasion to recommend their employment, and can only propose to await the result of longer experience.

III. *On the mode of attaching the engines and carriages together, the kind of break employed, and the method of deadening shocks.*

A very important question was next discussed by the Commission, viz., whether more than one locomotive ought to be allowed to be attached to a train. The conclusion arrived at was, that there was always disadvantage, and sometimes danger, attending the use of more than one engine. It is, in fact, impossible that the engineers of the different engines should always act in concert; and moreover, if the foremost engine should meet with any accident, rendering it necessary to stop, the hinder one, continuing to progress, would most likely throw it off the rail, if the speed were considerable.

The Commission is therefore of opinion that more than one engine ought not to be used to one train, except, in certain cases, on railways in the environs of Paris, or other large cities, where there are an immense number of passengers.

Under these circumstances, when it is absolutely necessary to use two engines, how are they to be attached? If one of them is a six-wheeled engine, which of them is to be placed in front; and if both are six or four-wheeled engines, should the heaviest or the lightest be placed in front?

In order fully to answer these questions, the Commission thinks fit to remark that the principal danger consists in the probability, in certain cases, of the front engine being pushed forward by the hinder one; in which case it is liable to go off the rails, and might thereby cause very serious accidents. Under these circumstances, as the six-wheeled engines are more firm than the four-wheel, and are for that reason less likely to get off the rails, when two engines, one of six and the other of four wheels, are to be employed in one train, the six-wheeled one should be placed in front. For the same reason, when two engines of different weights are employed, it is desirable to place the heaviest foremost.

The Commission adds, that it will be better to have both engines exactly alike, and that the principal point to be observed when two engines are employed is, never to allow the hindmost one to be driven at a greater speed than the foremost, and also to take care that the driver of the front engine has the driver of the other engine under his control.

The next question discussed by the Committee was, whether, as regarded safety, the position of the engine in front or behind the train was material. With respect to this, it appeared evident that the engine-driver, if placed behind the train, could not easily see what was going on in front, and that, therefore, there would be great danger of his not perceiving any obstacle. The Commission was therefore decidedly of opinion that the locomotive ought never to be attached to the hinder part of the train.

Having thus disposed of the questions relative to the engines, the Commission inquired into the different plans employed for linking the carriages together. There appeared to be three:—The first consists of chains of a certain length, leaving a certain space between the carriages, independently of that allowed for the play of the springs. The second consists in the employment of moveable bars, which also allow of the play of the springs, but unite the carriages more rigidly than the first plan. The third, and last plan, consists in uniting the carriages rigidly together, by screws and keys.

On comparing these plans, the Commission remarked, that as regarded the first, independently of the disadvantage it possessed of causing unpleasant shocks in starting, serious accidents might be occasioned, in the case of a violent shock, by permitting the carriages to run over each other. It was, therefore, considered that the best mode of uniting the carriages would be by rigid fastenings acting upon springs. By this means, in case of a collision, the train would offer the resistance of a solid mass, and there would be no danger of the carriages running over one another.

The only disadvantage of this plan would be, requiring more power from the locomotive; but this is a minor consideration, when the safety of the passengers is concerned. The Commission was therefore of opinion, that the carriages should be united in such a manner as to allow of the buffers being always in contact.

Another no less important question was, whether vehicles with cast-iron wheels ought to be allowed between the tender and the passenger carriages. This was decided in the negative, as it appeared that cast-iron wheels, running with great speed, would soon wear, and were liable to break; in which case, the train would be almost sure to be thrown off the rails.

The Commission having thus decided upon the best means of forming the trains, as regarded the safety of the passengers, the subject next to be considered was the best means of regulating the speed of trains, and freeing them as much as possible from danger of accident, to which they might be exposed.

The most usual causes of accidents may be resolved into one, viz., a sudden shock, produced either by the locomotive coming into contact with some obstacle; by the breaking of an axle; or by running off the rails.

As regards the breakage of axles, accidents likely to occur therefrom may be most readily prevented by the promptitude and intelligence of the engine-driver.

With regard to shocks and sudden stoppages, what tends most to increase the danger is the speed at which the train is travelling; in order therefore either wholly or partially to obviate them, it is desirable to find out the best means of slackening the speed at pleasure. For this purpose brakes are used, which act by pressing on the periphery of the wheels of one or more carriages of the train, and by that means diminish the speed.

The brakes most commonly used upon railways may be divided into three classes.—1st. Brakes acting on one wheel only of each axle, and pressing on one side of the wheel.—2nd. Brakes acting on one wheel of each axle, but pressing against both sides of the wheel.—3rd. Brakes acting on both wheels, and on one side of each wheel.

Neither the first nor the second ought to be used, as they have a tendency to dismount the wheel opposite to that on which they act; and the first, especially, has a tendency to destroy the parallelism of the axles, which might occasion serious accidents.

The third class of brakes possesses neither of these inconveniences. It is true that, by acting on one side of the wheel only, the whole of the pressure will be exerted upon the pivot of the axle; and although this pressure is equal to the weight supported by the wheel (and consequently the pivot of the axle does not sustain much more strain than under ordinary circumstances), the best plan would no doubt be that by which a pair of wheels would be acted upon on both sides simultaneously; the efforts of inventors should therefore be directed to this object.

With regard to the brakes now in use upon railways, the Commission was not sufficiently informed upon the subject to be able to recommend any one of the proposed plans, and it appears that careful experiments would be necessary to decide the question. The following are the facts to be considered in these experiments:—

1st. What is the time necessary for enabling the person having the management of the brake to produce sufficient pressure on the wheels to stop them, including the time necessary for signalling?

2nd. What is the time necessary to elapse, and what distance will have been travelled, before a carriage, travelling at various speeds and provided with efficient brakes, can be stopped?

This experiment ought to be tried many times, under various atmospheric tendencies, in order to test the effects of dryness, dampness, or hoar-frost, or the effect of throwing sand on the rails, as was proposed and practised on the railway from Saint Etienne to Lyons; the experiments should be made upon levels as well as inclines.

3rd. What is the time necessary to elapse, and the distance to be run over, in order to stop a train composed of a locomotive and tender, and six or eight ordinary carriages, on different inclines and under various atmospheric influences, the carriages being provided with brakes, and driven at various speeds, making use,—1st. Of the tender brake, the steam being shut off.—2nd. Of one, two, or more of the carriage brakes, the steam being shut off.—3rd. Of all the brakes, and reversing the engine; in fact, employing all the means known for stopping.—The Commission, in considering the question as to the propriety of skidding all the carriages, is of opinion that it would perhaps be advisable, when proceeding at a speed of from twenty-five to thirty miles an hour, to adopt this method; but generally, in a train composed of a locomotive, tender, and seven or eight carriages, only one of the carriages is provided with a brake, and the Commission wished to ascertain which carriage it should be applied to.

It was remarked that, independently of the momentum acquired by the carriages respectively, each of them is, at the time of stopping, pushed forward by the one behind it, especially when connected loosely by chains; it therefore appeared advisable to provide the last carriage with a brake, which should act at the moment of stoppage, and, by thus offering a resistance, the force of which may be mathematically calculated, tighten the connecting chains or rods of the front carriages.

Should any apparatus be used to deaden shocks? And if so, what position ought it to occupy?

On this subject, the Commission is of opinion, that if it were possible to throw the whole or the greater part of the force of the shock upon any inert body, the safety of the carriages would be much increased; and as to the place it ought to occupy in the train, the Commission considers it best to place the brake between the tender and the passenger carriages.

Several kinds of apparatus adapted for this purpose, were presented. Some of them were composed of metallic springs, which would be gradually compressed by the shock, and by that means slacken the speed of the train; and others were composed of air-springs acting upon the same principle.

With regard to the former, they would be the more efficacious, in proportion to the time they allowed the train to run while compressing the springs; but, at the same time, the length of the springs must not be such as to cause danger of running off the rails when traversing curves. On the other hand, it will be understood, that it is advisable to construct them so as to offer the greatest possible degree of resistance; their weight must not, however, be greater than that of an ordinary loaded carriage. In order to produce the desired effect, the apparatus should be so constructed as to allow the train to bear the greatest possible compression without injury; occasion no danger in traversing curves; and offer the greatest possible resistance with the least weight.

With regard to the air apparatus, it would not act efficiently unless made of very large dimensions, so as to present a large body of air to be compressed; this kind of buffer is therefore inadmissible, from its bulk. In fact, as the density is in an inverse ratio to the volume of air, the apparatus would not act until the piston, meeting with resistance from the air, would be nearly at the end of its course, at which point it would not offer any efficient resistance to a shock of any considerable violence.

It appeared to the Commission, that an apparatus offering great resistance would not act so efficiently as one which would be broken by the shock of a collision.

It was thought that it would be advisable to propose a prize to the inventor of any apparatus, which, after being in use for some time, was found to act efficiently.

There are some preliminary arrangements, as regards safety, to be considered. One precaution which has been adopted consists in interposing between the tender and the passenger-carriages as many empty carriages as there are locomotives: this precaution may, in most cases, preserve the passengers from injury.

IV. *Of Rules to be enforced by Law in Working Railways.*

The first point to be considered, as regards safety in railway transit, is the working with perfect regularity, and subject to fixed rules, which must never be infringed; it is clearly the duty of Government to legislate on this subject.

By the present laws, railway companies are empowered to frame bye-laws for working, but they are obliged to submit them for the approval of the higher authorities. This is a salutary regulation, and the companies ought to be bound to inform the Government, in good time, of the hours fixed for the departure of the trains, as well from the termini as the intermediate stations.

Express trains must be used as rarely as possible, and only when they are absolutely necessary: their approach must be signalled along the line.

The Commission has not given much attention to cases where accidents might happen from two trains meeting on the same line. On railways, by which a great number of persons travel, there are always at least two lines of rail, and the only likelihood there is of one train running into another, is when they are both travelling the same way; and even this might be avoided if the officials were to adhere to the times fixed by the authorities for departure from the termini, and those fixed by themselves for the intermediate stations.

Independently of the shocks which may happen when the trains are in motion, passengers have sometimes been seriously injured from shocks

occasioned on stopping at the termini, by coming into contact either with the walls or the carriages. This occurs either from the ignorance or negligence of the engineers, and sometimes from a derangement of the brake not allowing the train to be stopped with sufficient promptitude.

In order to obviate this, it would be advisable to direct the engine-drivers to stop the train completely before reaching the place where the passengers are to alight. When a train is in progress, it is indispensably necessary for the engine-driver to be constantly warned of all that passes on the line; and for this purpose there must always be, between the engine-driver and station-guards, certain signals, which may be readily understood by the latter; and by means of which the station-keepers may always communicate with each other. Signals between the engine-driver and guard of railway trains either do not, for the most part, exist, or are very imperfect. It will, nevertheless, be readily conceived, that many casualties may arise during the progress of a train, of which it is necessary for the engine-driver to have notice,—as in case of the breaking of an axle, the carriages running off the rails, &c. The Commission thinks that Government ought to direct, that in each passenger-train there should be a guard, furnished with the means of communicating the necessary intelligence to the engine-driver.

Another subject of great importance in railway transit is the question,—at what speed they should travel? and on this head, the Commission deliberated, first, whether it would be advisable to fix a maximum speed; but it was found, that a speed which would be without danger on very slight inclines and curves of large radius, would be extremely dangerous on steep inclines and curves of small radius, and which were to be traversed by heavy trains; it is, therefore, proposed to fix a maximum speed for each road, regard being had to the inclines and curves on each line, and also to the trains to run upon it.

It would also be very useful for each engine to be furnished with an apparatus for indicating (permanently and independently of the will of the engineer) the maximum speed of the train at any period of its journey.

Note on Experiments made upon the new line of rail at Saint Germain, with a Locomotive constructed by M. Flachat.

The town of Saint Germain is situate on an elevation of about sixty yards above the plain upon which the line of rail terminates at the Pecq Bridge. The atmospheric railway overcomes this difference of level by means of a series of gradients, forming altogether a parabolic curve, sloping towards the earth, and terminating in a gradient of 1083 yards in length, and having an inclination of 35 yards.

M. Flachat, who was charged with the superintendence of the works, acknowledged the necessity of constructing a powerful engine, capable of propelling upon steep inclines the materials necessary for the construction of the road, and the apparatus for the atmospheric plan. The engine is now employed for drawing earth from cuttings in the forest of Saint Germain: the wagons running up empty, and returning full.

The experiment made on the 17th of June last, was for the purpose of ascertaining the maximum weight the engine was capable of drawing on the above incline. The train consisted of four wagons loaded with earth, and weighing, when empty, between three and four tons. One wagon was found, when loaded with earth, to weigh nearly 12 tons. The load, on descending, was therefore—

The Engine, weighing about	20 tons.
The Tender	9 ..
Four loaded Wagons	44 ..
A Brake Carriage	3 ..
	76 tons.

The train started at a moderate speed, with the regulator entirely closed. The train having once stopped, it was found to be impossible to ascend again. One, two, and three wagons were then successively emptied, and it was not possible to ascend the incline until this was done. The train therefore consisted of—

The Engine	20 tons	29 tons dead weight.
The Tender	9 ..	
Three empty Wagons	9 ..	28 tons useful weight.
A loaded Wagon	11 ..	
A Brake Carriage	8 ..	

This experiment was made twice, and gave the same results both times.

The engine was working at a pressure of five atmospheres; the power it exerted, supposing the action of the steam to be the same throughout, was therefore about 3 tons 4½ cwt. The resistance to be overcome was as follows:—

	tons.	cwt.	lb.
Friction of various kinds, reckoned as 200th of the weight (76 tons)	0	7	56
Action of gravity	1	16	0
	2	3	56

There remains a difference of 1 ton, 1½ cwt., owing to the diminution of pressure, and additional friction of all kinds, and other casualties. It will, of course, be understood, that on less steep inclines this tractive power will be much increased.

REVIEWS.

The High Pressure Steam Engine investigated: an exposition of its comparative merits, and an essay towards its improved construction. By Dr. Ernst Alban, practical machine maker, Plau, Saxony. Translated by W. Pole, F.R.A.S. Parts I. and II. Weale, 1847. 8vo., pp. 145. Six plates.

The object of this book is a novel one. It is to advocate the superiority of the high-pressure over the low-pressure engine; and the omission of all exceptions in favour of the latter kind of engine leads to the inference, that the author recommends the adoption of the former under all circumstances, and for all purposes.

Dr. Alban tells us that he is a practical manufacturer of engines; that he has been engaged for thirty years, without intermission, in studying this subject; that he has made a large number of engines of various dimensions and varieties; and has been in the constant practice of experimenting with a view to their improvement. A man who brings forward his opinions thus authenticated by long experience, has a right to demand some attention to them, and will generally have something to say which is worth listening to. This is the case in the present instance; but while full credit is to be given to our author for his practical knowledge, it must be premised that he has confined his attention almost exclusively to engines worked by high pressure, and consequently is far more qualified to speak respecting their advantages and capabilities than respecting those of low-pressure engines. Possibly, had he studied the latter more, he would have thought better of them.

These considerations apply exclusively to Dr. Alban's practical knowledge—his theoretical opinions are to be criticised independently and abstractedly. We shall find that his physical conceptions, though often clear and vigorous, occasionally lead him into serious errors. The translator of this work sets out with high professions of the necessity of theoretical accuracy, and laments the aberrations of the unlearned in a manner which to some of his readers will appear amusing. He is very caustic respecting the unhappy frequency of blunders arising "from the practical methods adopted by ignorant men," and complains that "unhappily, in most cases, the unfortunate public have to pay for the schooling of their engineer,"—"unless the engineer has a knowledge of principles to guide him, and a capability too of reasoning on those principles." After this wholesale condemnation of engineers, it might have been hoped that Mr. Pole would have at least avoided the errors which he denounces, and that he would not have published in an English form several notions greviously at variance with the said "knowledge of principles." He professes to correct his author's mistakes, but the worst of them are passed over uncorrected, and apparently unobserved.

Of the two Parts of the work before us, the first is theoretical; the second refers to details of construction. We shall for the present confine our attention to the former, in which the author examines the objections brought against high-pressure engines, and replies to them, and then proceeds to a serial account of the advantages peculiar to these engines.

The objections may be considered first—they are principally these five. 1st. The danger of explosion: 2nd. The loss of heat: 3rd. The relinquishment of that power which arises from condensation: 4th. The consumption of oil and grease for lubrication: 5th. The wear and tear of metal from the rapidity of motion. We will take these objections in their order.

The first objection—respecting the danger of explosion—may be considered to be of a two-fold nature: for we have to ascertain primarily whether a high-pressure boiler be more likely to explode than a low-pressure boiler; secondarily, whether the results of an explosion are more disastrous in the former case than in the latter. Our author does not make this distinction; but it is obviously necessary for the complete examination of the subject. In comparing the probabilities of an explosion occurring in either case, we must, of course, for the fairness of comparison, pre-suppose that, *cæteris paribus*, the metal of the boiler is always made of a thickness proportional to the intended steam pressure: that is, that a boiler intended to bear a pressure of four atmospheres, is made twice as strong as one intended for a pressure of two atmospheres, &c. Unless this supposition be made, an accurate general comparison of the probabilities of explosion would be impossible; and, moreover, the precaution is one so palpably necessary, that no man of common prudence would neglect it. This being premised, we proceed to our author's first view of the case.

"Every boiler may become supercharged with steam when the quantity drawn off is less than the quantity generated, and when the safety-valves, in

consequence of imperfections in their action or condition, do not properly perform their duty. Therefore, in so far as similar safety apparatus are used for both high and low-pressure boilers, they must be liable to similar interruptions in their working. Experience has shown this very often, and it has been found that even the vertical open-mouthed feed-pipes of low-pressure boilers, which act as escape-pipes when the boiler pressure is too great, (these are wanting in marine engines,) are not always secure. If then an overfilling of the boiler with steam is equally possible in both high and low-pressure engines, both are liable to danger from this source; as the strength of the metal is adapted to the working pressure, and therefore the proper elasticity for which the vessel is constructed must be exceeded when such an occurrence happens. But there is an advantage on the side of the high-pressure engine, for the elasticity must be increased in a much higher ratio than with the low-pressure engine, before it overcomes the pressure at which the boiler is proved (usually three times the working elasticity); and therefore a much longer time will elapse before absolute danger arises. For example, in a boiler working at eight atmospheres, it will take a much greater lapse of time for the pressure to rise to 24-atmospheres, than it would to reach 12 lb. per square inch in a boiler working at 4 lb.; and these would be the points at which danger may be supposed to arise in the respective cases. This gives a key to the experience of late times, that as great a proportionate number of low as of high-pressure boilers have exploded, as well in England as in America and France; and that among the latest instances, the accidents with the former have reached an alarming extent."

This extract brings us to the first allegation, that it takes a longer *time* to overcharge a high-pressure than a lower pressure boiler. The general truth is not stated with sufficient precision; it may be explained by the following example: by referring to the best tables for the relative volumes of steam at different pressures, we find that any given quantity of water will produce 249 times its bulk of steam of eight atmospheres' pressure, and 1669 times its bulk of steam of one atmosphere. Consequently, to fill a boiler with the latter or low-pressure steam, rather less than seven times as much water would be required as would be necessary for filling it with the former or high-pressure steam.

Now, it has been ascertained that the pressure in the boiler has no influence on the rate of vaporization—that is, with a fire of given intensity and a fire-box of given dimensions, the same number of pounds of water will be converted into steam in a given time, whether the boiler-pressure be one atmosphere or eight atmospheres. Coupling this consideration with that in the preceding paragraph, we arrive at the conclusion that the overcharging a boiler which can only resist a pressure of one atmosphere, takes about one-seventh of the time required for overcharging a boiler which will bear a pressure of eight atmospheres. In order to the accuracy of this conclusion, it is requisite however to suppose nothing altered but the boiler pressure, and that the capacity of the boiler, the intensity of the fire, and the dimensions of the fire grate, are in all cases the same. With this proviso (which is not stated by Dr. Alban), we may establish the general conclusion, that a low-pressure boiler is overcharged in a shorter time than a high-pressure boiler.

Our author then proceeds to consider the causes of explosion, and details the various hypotheses which have been suggested, such as that of the generation of an explosive gas from the decomposition of the water—the generation of hydro-electricity—and the sudden conversion of water into steam by coming in contact with overheated parts of the boiler. The latter of these hypotheses is by far the most probable; but there is one important point of agreement in them *all*, namely, that the ultimate or inducing cause of an explosion is the sinking of the water too low in the boiler, and the consequent over-heating of the metal. To this point, therefore, attention must be confined, when the safety of high-pressure and low-pressure boilers is compared. We have simply to ascertain which of the two is most liable to be overheated. One of the principal causes of this evil is

"Too great an accumulation, either general or partial, of scale or earthy sediment in the boiler. These substances being bad conductors of heat, prevent, when in large quantities, the proper distribution of caloric to the water, or at least injuriously retard its transmission. The heat of the metal then increases to too great an extent, and may frequently rise to incandescence. Sometimes it happens that the layers of deposit arrange themselves in such wise as to leave interstices to which the water cannot penetrate: now if any of the adjacent portions become cracked, the water will suddenly find its way upon the hot metal, and will cause a local explosion, thereby loosening the scale not only from the part previously affected, but for a considerable distance round, and consequently increasing the contact of the water with the heated metal. This produces a rumbling commotion in the water, which, if the incandescent spot be large, may be in the highest degree injurious to the structure of the boiler. The steam thus suddenly formed augments the pressure, and hence again increased danger may ensue, particularly as the spot overheated will have been rendered more susceptible of damage. It has often been remarked that explosions were immediately preceded by the rumbling noise alluded to above. The high-pressure engine has in this respect also an advantage over the low-pressure, in that the sediment, when the elasticity is great, seldom attaches itself firmly to the sides of the boiler, but collects in a loose state, and is easily removed."

The comparison proceeds in a fair manner as follows:—

"Boilers which are fitted with imperfect water gauges or feed apparatus, are particularly liable to the evils of a partial exposure of the fire surface, and unfortunately these defects are but too common, particularly with high-pressure engines. The same liability to danger is also incurred where internal fire-tubes are inserted, or where the water space is too flat and confined, and is exposed in an injudicious manner to the flues. When tubes are introduced, they seldom lie deep enough under the water level, and are therefore soon left uncovered by an accidental slight depression of the latter; and if the water chambers are too confined, the water will be often driven out during violent ebullition. Marine and locomotive boilers are particularly liable to this. A steam boat boiler which burst at Hull (an account of the accident, with a description of the appearance of the boiler after the explosion, will be found in the '*Civil Engineer and Architect's Journal*,' August, 1838, p. 283) furnishes an example of such an improper make. Both imperfections were united in its construction, and the collapsed fire-tubes showed that the metal of these parts had been overheated in consequence of the water being driven out of the too contracted surrounding chambers, and that by such overheating the parts were weakened, and at last suddenly gave way to the pressure. It is much to be regretted that marine boilers are usually subject to the evil of too confined and too shallow a water space; because the ship's motion renders them particularly liable to the exposure of the fire-tubes: the use of sails increases the mischief, for when the ship has lain over on one side for some time, her righting or careening will throw the water back upon any portions of the metal that may have become over-heated, and thus danger may ensue in proportion to the length of time the parts have been exposed and the degree of exposure. Hence we find the majority of explosions occur on board steam boats, and proportionately but few on shore.

Now since all marine boilers, as well for low as high-pressure, are liable, if injudiciously constructed, to similar dangers of the kind we have named above, no conclusion to the prejudice of high-pressure engines can be drawn from such accidents. Indeed of late years a general comparison has been in favour of the high-pressure system.* One reason why low-pressure boilers must, under the evils above-mentioned, be less secure than high pressure, is that in the former the ebullition is much more violent, and the water thereby more liable to be expelled, whereas under a great elasticity the bubbles of steam generated take a smaller volume, the ebullition goes on more quietly, and therefore the danger is lessened.

The common chest form of low-pressure boilers with straight sides tends to increase the liability to the exposure of parts heated by the fire, especially if furnished with internal flues, as is generally the case with marine boilers. The large flat surfaces easily bulge out by an increased pressure within, and the consequent augmentation of cubical content causes a sinking of the water surface; after which the restoration of the elasticity to its original degree may throw back the water over the spots it formerly left, and thus the source of danger is at hand."

The last mentioned evil is not enlarged upon in a manner corresponding to its importance. It may be demonstrated that boilers with flat sides are subject to much greater strain than those which are curvilinear in every part. If the boiler be of the form known in geometry as a solid of revolution without flat ends (that is, if every section perpendicular to its axis be a circle), the elastic pressure within will not tend to *bulge* it. We think it may be shown that, in this case, the tension of the metal is direct or tangential, and that there are no transverse strains, analogous to those of a deflected beam or girder. But where *flat surfaces* are exposed to the action of steam, there is a tendency to make them belly out, like the sails of a ship. In this case, the metal *is* subject to transverse strains, and in consequence of the tendency to bending, will be subject to forces of both extension and compression (like a deflected beam); these forces greatly exceeding those arising from direct tension in the solid of revolution. It will be seen therefore that boilers with flat sides have a great disadvantage—in addition, it must be observed, to the weakness at the angles,—from the imperfect connection of the plates.

Another cause of danger in low-pressure engines, which Dr. Alban insists upon, is their great size.

"The greater the content of a boiler, the greater surface it must offer to the pressure of the steam, and the greater danger it must be subject to. This truth is so self-evident, that it is incomprehensible how it should be so universally neglected. The size of many boilers at present in use is truly astounding. I have not unfrequently seen them as large as 5 or 6 feet in dia-

* Vide 'Echo du Monde savant,' No. 24, p. 178. Up to the year 1834, only twenty explosions had occurred in America with high-pressure engines, while thirty-two had happened with low-pressure; and it is well known how common the high-pressure engine is in that country, particularly in the Western States. At a later date, the proprietors of steam boats in North America have stated, in a memorial to Congress, that since the more general introduction of high-pressure steam, the number of accidents has not only not increased, but become lessened in an extraordinary degree.

meter. Such boilers ought indeed to be named *exploders*, and the legislative restriction as to the amount of pressure to be used with them is, as far as it goes, a salutary measure. Still better would the law stand if it began at the other end, and limited the size of the vessels instead of the elasticity of the steam within them; for such an enactment would be free from the objection of discouraging the use of high-pressure steam, now promising so much advantage to industry. We can scarcely hope, however, for the full realization of our wishes in this respect, unless a bold and enlarged view is taken of the system; for, as I shall hereafter show, the high-pressure engine cannot be made to display its advantages with steam under about six atmospheres' pressure. A compulsory enactment restricting the size of the generating vessels would tend much towards promoting the use of steam of such high pressures, and, by producing a necessity for acquaintance with the working of the engine, would undoubtedly further its real improvement."

The comparison is not, however, here stated quite fairly. It is true, that all things else remaining the same, the tension of the boiler increases with its size; but then we set out by supposing the strength of the material increased in like proportion. The author himself insists that it be presupposed, *in limine*, that the thickness of the metal be proportioned to the tension to be resisted; and, as we have already said, it is absurd to institute a comparison on any other terms. In objecting therefore to the great size of low-pressure boilers he should condemn—not their weakness (which is supposed to be provided against)—but the great weight of metal required to make them sufficiently strong.

The relation between the thickness of the metal and the dimensions and pressure of the boiler, may be easily determined in most cases; and we intend to lay before the reader, in a separate paper, the means of calculating, with great facility, the proper thickness of a boiler of given form and size, in order to sustain a given pressure. For the present, however, we may observe, with Dr. Alban, that when the plates of a large boiler are increased to a thickness proper to its dimensions, they may become so thick as to be liable to crack from the sudden application of heat. This is a source of danger altogether independent of those hitherto considered,—it must be prevented either by making the plates of metal of superior temper and tenacity; or by gradual and careful heating; or lastly, by reducing the size of the boiler, and consequently, the thickness of its plates. Dr. Alban must, however, recollect that, in respect to this danger of cracking, low-pressure and high-pressure boilers are frequently on a *par*. He says—

"It is indeed customary to give to boilers of great size a proportionate thickness of metal, but this helps the case very little; for experience has shown that thick plates, especially if of cast metal, are more liable to crack by the action of the fire than thin ones; inasmuch as the temperature of their two sides, exposed respectively to the fire without and the water within, does not quickly assimilate; whereby unequal expansion and contraction ensues. It is moreover a difficult matter to determine what the proper strength ought to be in proportion to the diameter and the pressure, and there is a great difference of opinion among those who have given their attention to this point. It must also be noticed, that thick vessels tend more to retard the transmission of heat to the water than thin ones, although this fact seems often to have escaped the notice of engineers."

But how extremely unphilosophical is it to urge this as an argument against low-pressure boilers exclusively! A boiler of large dimensions and low pressure may require the same thickness of metal as a boiler of small dimensions and high pressure.

The second objection against high-pressure engines—the loss of heat—we must, for the sake of brevity, dismiss with the following brief consideration, which, in fact, embraces the sum of our author's arguments. By a well-known property of steam, ascertained by Watt and many others, the sum of the latent and sensible heats is constant at all pressures, and therefore the same fire will evaporate equal quantities of water in a given time, whatever be the boiler pressure. Now, it may be demonstrated mathematically that steam acts with most effect when used at a high pressure and worked expansively. Consequently there is, *cæteris paribus*, a greater economy of fuel when the steam is generated at high pressure.

The third objection—the relinquishment of that force arising from condensation—is stated correctly by Dr. Alban, except in that he under-estimates the amount of power obtained in practice by condensing the steam.

"Partly through imperfect condensation, partly through the working of the air and cold water pumps, and from other causes of the same description, the useful effect of low-pressure engines is reduced from about 17 lb. per square inch absolute pressure upon the piston, to about *seven*, as made available in power obtained; so that the use of condensation only in reality offers a gain of from 4½ to 5 lb. per square inch, or one-third of the atmospheric pressure..... The objection loses in weight as we use steam of higher pressure, and at seven or eight atmospheres is scarcely to be considered, because the surface of the piston becomes proportionately less as the elasticity is increased, and therefore the loss of the vacuum is less to be felt; while the advantages of the system are increased by such increase of elasticity. When the pressure used is too low, for example, only two or three atmospheres, as is most common, the loss may be important, and the advantages of the high-pressure system are not sufficiently developed to cover it. For instance, an engine of 10-horse power at two atmospheres' pressure, will require about twice as much steam as a condensing one of the same power: it must be of about the same dimensions, and by the want of a vacuum must be supplied with steam of a double elasticity to produce the same effect. Here, therefore, a power of ten horses will be sacrificed by the want of the vacuum; that is, as much as the whole power of the engine. But if a pressure of eight or ten atmospheres be used, and the principle of expansion applied, the proportionate loss, by the sacrifice of the vacuum, will be scarcely equal to 2-horse power out of ten,—a loss of very trifling weight when compared with the advantages possessed by such an engine over a low-pressure one. Yet more in favour of the high-pressure engine would the comparison be if we could substitute steam of sixteen atmospheres for that of eight; but unfortunately, through practical difficulties in the working of the machinery, our limits of available elasticity are at present too confined."

We may here observe, that elsewhere Dr. Alban recommends that the steam should always be generated at a pressure of eight or ten atmospheres, or 120 lb. to 150 lb. to the square inch. He speaks of employing what we should consider excessive pressures, with great composure. "Once," says he, "I worked an engine, for the sake of experiment, to a pressure of 1000 lb. on the square inch, and it was found that under this tremendous pressure, the engine itself remained perfectly firm and steam-tight"! He tells us also, that in the ordinary working of his steam engines "the steam makes its exit from the cylinder with a pressure of about three atmospheres," or 45 lb. Now, in English railway locomotives, steam is often admitted *into* the cylinder at the pressure with which Dr. Alban suffers it to escape. So that if it were possible for him to send his steam here when he had done with it, we might use it in working our locomotives. It seems scarcely possible that there can be any economy where steam is suffered to escape at this high pressure: for supposing it to be admitted to the cylinder at eight atmospheres, and to maintain uniform pressure throughout the stroke, the effective pressure is (8—3, or) 5 atmospheres: consequently, ⅜ths of the power is wasted. The reason assigned for expelling the steam at a high pressure exhibits some very odd philosophy:

"The steam leaving the cylinder would at the end of each stroke retain too little excess of pressure above the atmosphere, and therefore would blow out with too small a velocity, and leave behind an increased resistance to the piston. For example, steam of three atmospheres, expanded to three times its volume, would scarcely balance the atmosphere, and would thus have no tendency to blow out; while steam of two atmospheres similarly expanded, would sink so much under the atmospheric pressure, as to cause a very injurious counter-resistance to the piston from the entering air."

The phrase, "leave behind an increased resistance to this piston," is to us perfectly unintelligible. If the escaping steam be of high elasticity, it will doubtless have a great tendency to rush out by the eduction-port—but the same elasticity also acts to retard the motion of the piston. Of course, it is desirable that the steam should be got rid of with facility; and, in order that the piston may drive it out with as little resistance as possible, the escape-pipes should be made of ample size. But a "tendency to blow out" in the steam itself is of no advantage: for it has no power of itself to "blow out," after so much of it has escaped as to make the pressure of the remainder equal to that of the atmosphere. This remainder is expelled by the piston. Consequently, the piston will always have to drive out steam of *not less* pressure than the atmosphere—if it be much greater than the atmosphere, an unnecessary resistance is created. We come, then, to the conclusion that, in all engines in which the steam issues directly from the cylinder into the air, the issuing steam ought to be as nearly as possible of atmospheric pressure: in other words, if the steam be admitted from the boiler at a high pressure, its maximum effect is obtained by working it expansively and reducing it to about 15 lb. pressure, before the eduction-port is opened.

The fifth objection—the wear and tear of metal from rapidity of motion—our author tries to overcome by theoretical arguments: but the facts are too strong for him. That the rubbing parts of the best locomotive engines suffer a great wear and tear, due to the rapidity of motion, is an incontestable truth, which no arguments such as the following can get rid of:—

"It is inconceivable how the apparatus for transmitting the motion of the piston of a high-pressure engine to the machinery can be more subject to destruction, in regard to the durability of its joints, than in a low-pressure. If the power of each be the same, the machinery must have in each case equal strength: the stress to which it is subject is the same (or rather is less in the high-pressure engine, on account of the diminished prejudicial

resistance, and consequently diminished total pressure required), and there is no reason whatever why any required strength may not be given to these parts; so that if there should be apprehension from the unequal action of the piston when expansion is used, the strength may be increased at pleasure. Can the gradually diminishing force of the steam of an expanding engine do more mischief than the great shock which must occur in low-pressure engines, owing to their increased resistance? Then every one knows what sudden concussions are produced throughout the machinery of a condensing engine at the moment when the air-pump discharges its contents, at which instant the whole pressure of the atmosphere is suddenly thrown upon the area of the pump."

The parenthesis in the above extract involves a serious error. Even supposing we admit the "prejudicial resistance," and consequently the "total pressure," to be less in the high-pressure than in the low-pressure engine, it by no means follows that the strains of the individual parts are diminished. Those strains arise not merely from the external resistance, but also from the momentum of the working parts—or, to use mathematical language, they depend upon both the effective and impressed forces. For instance, a grindstone, though suffering no retardation from the friction of its axle, might revolve so fast as to be torn to pieces by its own centrifugal force. Similarly, the parts of a steam-engine may move backwards and forwards so fast, as to be fractured by excessive strains: these molecular strains being, moreover, far more dangerous where the motion is reciprocating than where it is rotary.

With respect to friction and attrition, also, it is undeniable that both increase with increase of velocity. If a drill, for instance, revolve slowly on a plate of steel, it will make no impression—if it revolve very fast, it will wear away a hole for itself immediately: the same considerations apply to the rubbing parts of steam engines. The review has, however, already extended to such a length, that we must not at present pursue the subject any further.

The Life of JAMES GANDON, M.R.I.A., F.R.S., Architect, *with Original Notices of Contemporary Artists and Fragments of Essays. From materials collected and arranged by his son,* JAMES GANDON. Prepared for publication by the late THOMAS MULVANY. Dublin: Hodges and Smith. 1846. 8vo. pp. 297.

Gandon, though an Englishman by birth and education, executed the greater part of his architectural works in Ireland. Those by which he is best known are the Custom House, Courts of Law, and King's Inn, Dublin.

He evinced early in life a strong predilection for mathematical and engineering drawing—pursuits for which some of the most celebrated architects have exhibited great aptitude. His professional career commenced under Sir William Chambers, from whom he acquired, besides his architural knowledge, a vast stock of general information: for his preceptor was a great traveller—born a Sweede, he had travelled much in the East, visited China, and wrote a book on its architecture—had resided several years in Italy, and minutely informed himself respecting Roman architecture. Gandon began life well: greatly to his preceptor's gratification, he obtained the first of the architectural medals given by the Royal Academy. This achievement took place in 1769, the year after that body was instituted, and is described in the following terms:—

"As soon as I read the advertisement for the distribution of these premiums, I was like a person electrified. I hurried to my friend Paul Sandby, who soon assured me that I could have no chance of success as a competitor for the gold medal in architecture, inasmuch as I was not elegible to be a candidate: the advertisement requiring that all the candidates should be students of the Royal Academy. This restriction certainly appeared a formidable obstacle to my becoming a competitor on the occasion. I had not much time for reflection, and the temptation was great, but I soon determined how I should act: I immediately entered my name as a student of the Academy, and attended all the lectures given by each professor. This was my only alternative.

"The Academy gave ample time for the candidates to prepare their respective productions. I commenced instantly to arrange my ideas on the subject given, which was a triumphal arch, commemorative of the Seven Years' War.

"The day at length arrived when the candidates were to send in their designs, and I was soon informed, to my very great gratification, that my design was declared the best, and that, consequently, I should obtain the gold medal.

"On the day fixed for the distribution of the medals, but before they were actually delivered, the architectural class were required to attend a Committee of the Academicians in a private apartment, in order to test their respective powers in impromptu composition. The different subjects were deposited in a vase, out of which each candidate drew his envelope, in which the subject was written. That which came to my hand was a park-gate, or rather an ornamental entrance to a park. Having first arranged my ideas, I then sketched out my design, and it was more admired by the Committee than my triumphal arch.

"When the medals were being distributed I was congratulated by many of the members, but particularly by Sir William Chambers, who expressed the pleasure he experienced on finding his pupil so early distinguishing himself."

Gandon next obtained the second of the premiums offered by the merchants of Dublin for a new Royal Exchange, and it appears from the biography that the award of first premium was influenced by private interest—a circumstance by no means unparalleled, as (we doubt not) many of our readers could attest. The next premium gained by Gandon was one of 100 guineas for the "new Bethlehem Hospital." This was the last public work for which he competed in England.

In 1779, he received an invitation from Lord Carlow to go over to Ireland, which he accepted, and was then appointed architect of the New Custom House. They manage matters in Ireland in a manner peculiar to themselves, as Gandon found out to his cost: for on his arrival, the opposition of individuals to the removal of the Custom House had become so strong, that it was actually necessary that he should secrete himself for several months. The foundations of the new building had scarcely been commenced before the mob were instigated to destroy the fences surrounding them. The architect received letters threatening him with personal injury, and in consequence always visited the works with a good cane sword; and "having been in early life a good swordsman (says he), I am determined to defend myself to the last." There were other difficulties however besides those of a personal nature.

"The labourers had scarce got down two feet below the surface when they came to water, which four men emptied with scoops as they continued to extend the line of trenches, which were carried on in short lengths, and, for convenience, of different depths. It became necessary to make dams across parts of them with sods, and to empty the water from the lower to the higher dam, until it was at last sent off in a drain prepared for that purpose, our pumps not being then ready. The ground was opened first at the north and continued round to the east front; then to the south end, where a boiling spring with sand appeared at about four feet below the surface, which filled up as fast as it was cast out. It extended for a considerable distance. Inch and half sheeting piles, about seven feet long, were driven down with a maul, to keep up the bank, and sods were fitted in layers between it and the piles, which prevented the sand from being washed out, thereby enabling the men to clear out the trenches to the depth required. The general texture of the ground was gravel, mixed in some places with a layer of blue clay and sand, under which was a hard strong gravel. When the trenches were thus prepared and cleared out, the rough masons then proceeded to carry on the first bench or course with all possible expedition with the black stone, and immediately filling in with earth, in order to give less water to the pumps. In the meantime another length, and of the same depth, was got ready, and an additional number of masons set to work. In this manner the whole was continued until all was brought up to the level of the ground.

"The quay wall or road on the south front was an old embankment, made about the year 1725; it was sixty feet wide at top, and badly constructed; the walls of black stone; its foundation laid on the surface of the strand; on the side next the river it was twelve feet high, but on the inside only eight; the filling between the walls was a sand used for ballast; the base of the foundations stood at least six feet above the bed of the river; the tide not only soaked under them, but filtered in several places through the joints of the masonry. It was, therefore, deemed most prudent to commence with the north-east wing, after the portion of the store-room, it being less liable to be incommoded with water from the river.

"Directions were now given for excavating that part of the centre of the south front for the cupola and portico; and as this advanced so near the river we were certain of much obstruction from the flowing of the tide, which was the only water that now gave us any trouble, for the springs were now pretty well dried and kept under. The pumps hitherto used were but thirteen or fourteen feet, we now used two of eighteen feet in length. As the ground altered in its texture towards the river, becoming more loose, with small sandy gravel, like that of the south-west angle, to which depth we had sunk, we deemed it prudent to bore it in several places which were near the angles of the front of the portico, but particularly where the walls of the cupola were to be erected, to the depth of eight feet below the then surface, and it appeared to be much of the same substance as that already described. A pile ten feet long and one foot square was driven down in the centre to nine feet depth; but after twenty strokes of the ram it could be driven no further, which assured us that we had got down to firm ground.

"Upon consulting with the principal artificers on the spot, it was thought advisable to desist from sinking any more, but to make an artificial foundation, in order to sustain the great weight of the cupola; but whether by piling or otherwise was submitted wholly for my consideration. This part of the work had long occupied my thoughts, and to it I had given every

attention, my conjectures having led me to expect great difficulties on this subject. I had nearly made up my mind as to the means I should adopt, and was the more strongly confirmed in my intentions, having remarked a circumstance which escaped the notice of those around me. Immediately after the pile had been driven, I perceived a small stream of water arising up close all around it, as if it had pierced a spring; and recollecting an observation in Labelye's* account of Westminster Bridge, 'that piles sometimes loosen and open fresh springs, which often make it very difficult to get rid of the water,' I was now apprehensive of just such an impediment. The great expense of preparing the piles, and the very long time it would take to drive so great a number as would be required, presented a strong objection to the use of them. I therefore gave directions to have a grating of Memel timber prepared, the timber to be one foot square, to have the upper ones notched down three inches in the ground pieces, which were to be bedded on a layer of cut heath, the whole ground being first correctly levelled; the interstices of the grating to be filled in with hard sound stock bricks, up to the level of the timbers, swimming in mortar composed of pounded roach lime and mortar well mixed, which answered nearly as well as tarras; over which was laid four-inch fir plank fastened down on the grating with oak trennels, which was all completed. The foundation walls were then set out on the 17th of September. The part directly under the cupola was laid with rough blocks of mountain granite in regular courses; in the first course was sunk an iron chain of flat bar, four inches wide and two and a half inches thick, into collars which were run with lead, but the bars were only covered with a cement of wax, resin, and stone dust. The rest of the foundation was done with the usual black stone, and was carried up to the plinth by the 16th October, 1782, thereby completing the whole of the foundations in one year and four months from the opening of the ground."

Another of Gandon's works consisted in several extensive additions and alterations in the Irish House of Lords—a large edifice, now converted into a bank. On the east side of the building a Corinthian portico was erected, in the construction of which many local difficulties, arising from the declivity of the ground, appear to have been overcome with great ingenuity and sound architectural taste. The dome, which was part of the original work, was destroyed by fire under circumstances which indicate that crotchets respecting ventilation have been fostered by other parliaments besides our own.

"This dome was subsequently destroyed by fire caused by the following circumstances. A man of the name of Nesbit, a smoke doctor, had been introduced to the Speaker, and recommended to his notice as a prodigy, in producing the greatest heat with the least possible portion of fuel. He was, therefore, employed to warm the House of Commons: and was suffered to cut into the walls, in order to lead flues into copper tubes, which he proposed to place on the angles of the dome. These tubes, from their nature, were very liable to be choked, and were often observed to be on fire, and large flakes of burning soot to fly out from them, to the great alarm of the neighbours, who gave repeated information of the fact, but to which no attention was given. The windows of the dome were also left very frequently carelessly open; the burning soot was driven in by the wind, and, resting on the framing, the wood-work took fire, and on the 27th February, 1792, totally destroyed the dome, during the sitting of the house. An inquiry was afterwards made as to the cause of the fire, but the real facts of the case were suppressed, and—the inquiry ended in smoke!

The foundation stone of the Courts of Law, or Four Courts as they are called, was laid in 1786; the erection of this building was impeded by the same factious opposition which attended Gandon's other works. The last public edifice erected under his superintendence was the Hall and Library and other offices of King's Inn, an ancient legal society constituted in a similar manner to the Inns of Court in London. This was the only building which Gandon left unfinished; the completion of the work he assigned to other hands on his retirement from professional life. His architectural labours extended over the long period of sixty years, and he died in 1824, at the age of eighty-two years.

Gandon's works appear to be characterised by the same merits and the same defects as those of his preceptor, Chambers. Judged by external appearance only, his works exhibit symmetry and unity, and impress the mind by their grandiose combinations: but their great defect is the presence of adscititious inconstructive ornaments. Gandon was essentially a Roman architect. In his time, almost all that was known of Classic architecture came from the Romans and Revivalists. The labours of "Athenian" Stuart and Revett were very recent and little known; and, until their time, there was an almost entire ignorance of Athenian, or purg trabeate architecture. The first volume of the Antiquities of Athens was published during Gandon's apprenticeship to Sir W. Chambers, and its appearance caused a great sensation. Still less was known of Pointed architecture—as Gandon himself shows in an essay at the end of the biography. It is not therefore to be wondered at that the dependance of decoration on construction was in his day little attended to.

The biography before us is well arranged, but there is too much gossip in it; notices of people of no note, and of transactions not worth recording. The architectural accounts are exceedingly meagre, and it is surprising that no technical or illustrative description of Gandon's works has been given. This omission greatly diminishes the value of the work. However, many of the observations show great taste and discernment, and the authors have the credit of recording the honours of one who in his day and generation laboured earnestly for the advancement of architecture.

* M. Labelye, a native of France, was the engineer of Westminster Bridge.—Ed.

Ancient and Modern Architecture, consisting of Views, Plans, &c. of the most remarkable edifices in the world. By JULES GAILHABAUD. Third series. Fermin, Didot, & Co. 1847.

The third series of this work is by no means inferior to the preceding parts of it. The conductors seem to have kept steadily in view their object of furnishing a complete set of illustrations of all known styles of architecture, from the earliest monolithic to the latest Italian and bastard Classic structures. Among the plates before us we have several illustrations of Celtic monuments, details, &c., of the arch of Septimius Severus, the tomb of Cecilia Metella, and the church of St. Ignatius at Rome. There are also numerous illustrations of St. Peters, at Rome, and St. Paul's, at London. We were especially pleased with the view of the interior of the church of St. Front, at Perigueux, which displays in an extraordinary degree the possibility of producing beautiful effects by the simplest means. This church, a very early specimen of the combination of the round and the pointed arch is remarkable for its severity; the interior has scarcely a single moulding or other ornament, and yet the effect is extremely impressive, simply because the architecture is *faithful*. It would be absurd to recommend the massive arches and piers of this church for modern imitation; but it it is far better (say we), that the architecture should be, as here, without ornament, than that it should be covered with the adscititious finery stuck upon buildings which by modern courtesy are called "Classic."

The letter-press of the series before us is not satisfactory—the descriptions are far too concise; and another defect is that they are published on loose sheets of paper, so as to be liable to be lost before the series is completed. Moreover, these "Sybilline leaves" are always dispersed (in the copies sent us, at least) in a most irregular manner. The history of Stonehenge accompanies the plates of Cologne Cathedral, and the description of the Temple of Vesta follows the views of a vile Parisian church of the sixteenth century. However, these defects are comparatively trivial, and might easily be remedied—we mention them because the work is a good one, and deserves all the care that can be bestowed on improving it. The following account of triumphal arches may serve as a specimen of the letter-press. The writer remarks, rather simply, that "the Greeks do not appear to have built any triumphal arches"—for which circumstance two very sufficient reasons may be assigned: first, that they could not, if they would, have done so; secondly, that they would not have done so if they could. The Greeks were ignorant of arch construction, in the first place: in the second place, they never made a single architectural member do duty for a whole building; and consequently had they employed arches at all, would have *made use* of them to support edifices, and not have displayed them for mere show.

"Triumphal arches are isolated portals erected at the entrance of towns, on public places, roads, or bridges; they are generally intended to commemorate a victory, sometimes also to perpetuate the memory of the real or supposed virtues of a prince, or to do honour to persons who have rendered great services to the state. In this last case they might more properly be denominated honorary arches. Not to mention here the great number erected for this last purpose in China, where arches called *Pay-leou* are often raised in honour of the most humble virtue, we might name a host of these monuments consecrated to civil virtues, such as the Arch of Ancona, built in honour of Trajan, to show the gratitude of the citizens for the improvements he made in the port, and bearing a dedication in which the name of the Emperor is associated with those of his wife and sister. We learn also from ancient inscriptions that monuments of this kind were occasionally erected in honour of the gods. It is very probable also that many of these arches answered a twofold purpose, being at the same time triumphal or honorary monuments, and gates of towns. We must be careful not to confound the subjects of the present article with those structures which are merely town-gates, like those of St. André and Arroux, at Autun, in the Department of the Saône and Loire, though they present a close analogy with triumphal arches. It is equally necessary to distin-

guish those arches with four fronts, called Janus Arches, erected in market-places as a shelter for buyers and sellers, and of which a very beautiful specimen is still extant at Rome, in the *Forum Boarium*.

The Greeks do not appear to have built any triumphal arches. All those in Greece or Asia Minor belong to the period of the Roman domination. The Romans must therefore be regarded as the inventors of these edifices, which, at first were nothing more than wooden structures raised across the streets where the triumphal processions passed. These fragile and temporary constructions undoubtedly supplied the original model of the form and decoration of triumphal arches. The descriptions in ancient authors inform us that it was usual to place musicians and men bearing trophies on the top of these monuments, while the spoils of the enemy and representations of battles covered the sides. Such were the nature and object of the structure, that the architect was afterwards required to produce in solid materials calculated to endure for centuries.

The first permanent triumphal arches were reared under the Republic, but they had no pretensions to splendour. Rosini says of them: "Primo rudes et simplices fuere cum præmia virtutis essent non ambitionis lenocinia. (*Antiq. Rom.* l. x.) The Arch of Romulus was rudely built of bricks; that of Camillus, of stones, almost as rough as they came from the quarry. For a long time these monuments consisted merely of a semicircular arch, surmounted by trophies and the statue of the conqueror. Such was the one which Cicero called *Arcus Fabianus*. Triumphal arches did not hold any honourable rank among the monuments of art until the time of the Emperors, and it is a remarkable fact, that, notwithstanding several were erected to Augustus, and very probably in his lifetime, Vitruvius does not even allude to them. At a later period, when a considerable number had already been erected, Pliny speaks of them as a modern invention.

Down to the time of the Antonines, arches generally consisted of a single arcade; but this rule was not always adhered to, as the arch built in honour of Tiberius, Drusus, and Germanicus, on the bridge of Saintes, in the Department of the Lower Charente, had two openings of equal dimensions. This last style, though commonly and judiciously reserved by the Romans for gates of towns, was also employed in the Roman arch at Langres, in the Department of the Upper Marne, probably for the purpose of expressing the equality of the two Gordians, who both received the honours of a triumph at the same time. The use of three arcades, at an earlier period, is proved by medals of Domitian and Trajan, relating to arches no longer in existence; but we find instances of one principal arch, with a small one on each side, for the first time in the Arch of Orange, belonging to the early years of the empire; again, under Septimius, and his successors, as well as in most of those belonging to modern times. Thus we see, in accordance with the usual course of human affairs, that the richness of triumphal arches increases in an inverse ratio to the merits of the actions and men whose memory they were intended to perpetuate.

The Engineer and Contractor's Pocket Book, for the Years 1847 *and* 1848. Edited and Published by John Weale.

This work contains a great deal of useful information suitable to the engineer. Besides the Standing Orders of the House of Commons and House of Lords, and Acts of Parliament relative to railways passed in 1844, and for constituting commissioners of railways passed in 1846, it also contains prices for mechanical engineering, an interesting description of the electric telegraph, numerous tables of reference, and memoranda. We recommend Mr. Weale, in a future edition, to arrange the work a little more systematically, and to withdraw the "Practical and Experimental Researches on Hydraulics," for the reasons stated in our review on that paper a short time since.

HISTORY OF ENGINEERING.

By Sir J. Rennie, President of the Institution of Civil Engineers.

The Address of Sir John Rennie to the last year's Annual General Meeting of the Institution of Civil Engineers, contains a most valuable and elaborate report on the progress of engineering during the past century. The length of the address precludes the insertion of the whole of it at once, but as from the importance of the subjects considered, it is necessary that the reader should be put in possession of the whole, the report will be completed in successive portions without any omissions:—

Before I attempt to point out the course which it behoves us to pursue as regards ulterior proceedings, let us pause and take a retrospective glance at the changes which have been effected in Great Britain since the days of that great man Smeaton, to whose genius and exertions Civil Engineering may be said to owe its establishment as a profession in this country. Previous to that period (1724), Great Britain may be said, comparatively speaking, to have been lamentably deficient in public works. There were no canals, railways, nor artificial harbours, or machinery, which at the present day would be thought worthy of the name; and the public roads were little better than mere tracks across the country. Communication between towns was difficult; and the few wheeled carriages in use were of a rude and inefficient description. The inland commerce of the country was chiefly carried on by transport on the backs of "*pack horses*;" and the old-fashioned term *load*, so commonly in use as a measure or weight, is a remnant of that custom—meaning a horse load. The luxuries, and even necessaries of life, were, consequently, extremely dear and difficult of attainment. Inland navigation, which was carried on in the rivers as nature had left them, was both tedious and uncertain; and this navigation, imperfect as it was, could only be adopted at times when there was sufficient water, arising from floods, or other causes; occasionally (but of this the instances were very rare) rude temporary stanches, or flash-weirs, were used to pen up the running water in shallow places; these weirs, or stanches, were then suddenly withdrawn, and thus the increased depth of water and the current enabled the boats to float over them; these were followed by rough unwalled locks; then by short side-cuts to avoid the difficult places of the rivers; in these side-cuts the pound-lock was introduced, with side-weirs to enable the floods to escape, and to supply mills with water, thus answering the double purposes of navigation and supplying power for machinery.

The above may be taken as the extent of improvement to which inland navigation had arrived in Great Britain up to the middle of the last century. The navigation of the ocean, depending upon the inconstant agency of the winds and tides, required months, nay, years, for communicating between distant quarters of the globe. The reckoning of a ship's course, during a long voyage, was most uncertain; neither chronometers, nor lunar observations, nor accurate instruments for making such observations, were known.

Steam Engine.

The Steam Engine (to the honour of inventing which so many individuals lay claim) had, in 1698, been so far improved, and was, for the first time, constructed by Savery so as to be employed as an efficient agent for raising water, was brought into active operation, in 1712, by means of a steam cylinder, into which cold water was injected for causing a vacuum, so as to enable a moveable piston to be impelled by the pressure of the atmosphere, and thus, by the intervention of a lever, to work pumps for raising water; this was further improved by Potter and Beighton (1713-18), so as to become self-acting; and thus Newcomen's engine, by degrees, became generally adopted for pumping water from collieries, and from a few rich mines, and for supplying the metropolis with water; but the consumption and expense of fuel was so considerable that, even great as were the advantages derived from its employment, still its application was very limited. After Beighton, followed Leupold, Hulls, Belidor, Payne, Blake, Fitzgerald, Emerson, and others, who made various suggestions, without, however, adding anything material to the engine as improved by Newcomen, Potter, and Beighton. The relation between the quantity of fuel consumed and the effect produced by an engine, had never been determined; and knowledge was wanting for the investigation of the important subject, until Black and Cavendish, in 1760-62, had made their experiments and discoveries on the combination of heat with bodies in their solid, liquid, and gaseous states. Notwithstanding the great advantages resulting from the employment of Newcomen's engine, still, for the reasons above mentioned, its application was very limited; wind and water were alone used as powers for driving machinery and working mills, which were rare, and only adapted for performing rude mechanical operations, such as grinding corn, fulling cloth, pumping water, blowing furnaces, hammering and rolling iron, and such other purposes as the feeble powers of human labour were unable to accomplish; and with the exception of the silk mills introduced from Italy by Sir Thomas Lombe at Derby in 1720, and which were worked by water, there was nothing in the nature of manufacturing machinery.

Engineers.

Smeaton, born in 1724, at an early age applied his ingenious and vigorous mind to the cultivation of philosophical knowledge and thought, for the benefit of mankind. He commenced his career as a mathematical-instrument maker in 1750; after obtaining some celebrity in the scientific world by his air-pump in 1752, he took up the subject of wind and water-mills, which had, up to that period, been much neglected, and soon made such improvements in them as greatly increased their powers and efficiency; he constructed several of both kinds according to his improved principles with great success, which were considered as models, and soon afterwards universally followed. In 1753 he was elected Fellow of the Royal Society; in 1759 he communicated his celebrated paper (being the results of his experiments in 1752 and 1753) on the natural powers of wind and water to turn mills and other machinery depending on circular motion, for which he obtained their gold medal. These improvements of Smeaton were of manifold importance, and produced, directly and indirectly, the most beneficial results, as they enabled a greater quantity of work to be performed both by wind and water, particularly during temperate and dry seasons; hence, better roads became necessary to carry away the increased produce of the mills; and when they were worked by water on rivers, the mill-owner became interested in the improvement of the navigation, and, by economising the water on Smeaton's plan, obtained one-third greater result with the same quantity, thus benefiting himself as well as the navigation. Windmills have been rendered still more perfect

than Smeaton left them, by making them self-regulating as to the extent of the surface of their sails presented to the action of the wind, according to the form and mode invented by Meikle in 1772; by Bywater in 1804, with an improved mode of clothing the sails; and still further by our valuable member, Cubitt, in 1807, who brought the system to perfection. Smeaton was amongst the first to point out the laws which govern the formation and maintenance of harbours; and, after undertaking a voyage of observation through Holland, he introduced great improvements in the draining of marsh lands (as at Holderness and the North Level), a subject which had up to that period been very imperfectly understood; and, by the design and construction of the celebrated Eddystone lighthouse in 1755-59, Smeaton introduced a new era in masonry, which forms a brilliant epoch in his valuable life, spent in the service of mankind, but more particularly for the benefit of his country. In 1765 Smeaton directed his attention to Newcomen's engine, and constructed a small engine, at his own house at Austhorpe, in order to conduct his experiments and obtain more accurate results in practice. By the judicious improvements which he introduced in the proportions and structure, he diminished materially the consumption of fuel, then an object of paramount importance, and soon after constructed engines on Newcomen's principle, which far exceeded anything of the kind hitherto produced: amongst these may be mentioned the engines at Long Benton, near Newcastle, and at Chasewater, in Cornwall; he thus rendered the system of Newcomen as perfect as it could be made. From the improvements of Smeaton on wind and water mills, we may date the foundation of the modern system of manufacturing, and from those in Newcomen's engine the modern system of mining.

Watt.—In 1736 Watt was born, and from his early years manifested symptoms of that genius and sagacity which, at a later period, enabled him to work out, with wonderful success, those grand discoveries which have immortalized his name. He began his career as a mathematical-instrument maker, and subsequently became an engineer. He proposed a plan for improving the river Clyde, and suggested the idea of the Caledonian Canal, but afterwards devoted himself almost exclusively to the improvement of the steam engine. His improvements, or rather inventions, may be stated, generally, as follows:—the separate condensing vessel, with an air-pump for exhausting the steam cylinder, instead of injecting cold water into it for impelling the piston on Newcomen's plan, by atmospheric pressure; in conjunction with Boulton, he brought these improvements into operation about the year 1773, and produced a still greater diminution in the consumption of fuel than Smeaton had done, thus rendering the application of the steam engine for pumping water much more general. In 1781 he invented the means of producing rotatory motion by the steam engine, first by the crank, and afterwards by the sun and planet wheel, thus rendering it applicable for the purpose of driving all kinds of machinery, which was a grand step towards the improvement of manufactures. In 1777-82 he invented the application of steam, with expansive action and with double action, alternately above and below the piston. In 1784 he invented the parallel motion, or working gear and valves, the governor, and other important details. All these improvements or inventions were carried into effect in an engine made by Boulton and Watt, in 1784, for one of the London breweries, and in 1785 in others for the Albion mills, which were the first steam-mills, now become so general; thus steam power was rendered available for working machinery of every kind, by following the best examples of this most wonderful and useful of all machines, which has so deservedly immortalized the name of Watt. The account of the extraordinary labours and inventions of Watt and his successors is well given by our valuable member Farey, in his excellent work on the steam engine, to which I would refer you, and also to the treatises by Tredgold, Arago, Scott Russell, and others.

Brindley.—About this period (1716), Brindley, who may be justly called the father of inland canal navigation in England, was born. He commenced his career as a millwright, and was withdrawn from that occupation by the Duke of Bridgewater in 1758, for the purpose of executing his great canal. Pound locks had been introduced long before on river navigations, and on the Exeter and Topsham Canal, which was commenced in 1581, and terminated about 1695; they were also used on the Sankey Canal in 1755, for the purpose of rendering Sankey Brook navigable; which was effected by making an almost entirely new channel. Brindley subsequently executed, with great success, the Trent and Mersey, or Grand Trunk, the Leeds and Liverpool, the Birmingham, the Forth and Clyde canals, in conjunction with Smeaton and several others, with all the necessary works belonging to them, which will ever remain as lasting monuments of his skill and genius in this valuable department of Civil Engineering. At an early period of the reign of George III., the importance of canal navigation became universally acknowledged as one of the greatest means then known, of facilitating the transport and reducing the cost of the necessaries and luxuries of life, and thus contributing to the wealth and prosperity of every part of the kingdom; those prejudices and obstacles by which, at the outset, every great improvement is surrounded, gradually began to give way, canals became popular, and superseded river navigation so much as to call forth the celebrated answer of Brindley to the question, "What is the use of rivers?"—"To supply canals." Engineers who had displayed such abilities in planning and executing works of the nature above described, began to acquire that importance as a profession which was soon after destined to work such a beneficial change, nay, almost a revolution in society, and accelerate so greatly the civilization of mankind.

Smeaton and Brindley were accompanied and followed by a number of able men in rapid succession; amongst whom Jessop, Whitworth, Mylne, Yeoman, Hensball, Golborne, Huddart, Rennie, Ralph Walker, Chapman, Telford, and others, all stimulated to exertion by the magnificent career before them, each contributing, more or less according to their several opportunities, great skill and invention of their own, in addition to that acquired from their predecessors. Favoured by the command of great funds (which were rapidly forthcoming as the success of the works already executed became manifest), better workmen and materials, new and improved machinery, steam power, and greater influence over the public mind, their operations were conducted upon a scale of magnitude, utility, and importance which gave a new character to the age in which they flourished, and advanced the prosperity of the empire.

Engineering Works.

Canals.—To attempt to enumerate all the various public works which then crowded each other in rapid succession, constituting the character of the profession, and entitling it to public confidence, would be both difficult and tedious; they are well known and duly appreciated, and it will suffice to point ont some of the most important. The Forth and Clyde Canal by Smeaton, (1768,) length 24 miles, depth 8 feet, locks 19 feet by 75 feet, top-width of canal 66 feet; the Ellesmere by Jessop and Telford, with its magnificent aqueduct across the Dee near Llangollen, consisting of 19 arches 40 feet span, the centre being 126 feet above the Dee, with a total length of 1020 feet, and a width of 12 feet, the piers of stone, and the arches and aqueduct of cast iron; the Caledonian Canal by Jessop and Telford, 22 miles long, depth 16 feet, locks 40 feet wide by 172 feet long, 8 feet rise, top-width of canal 110 feet; locks intended for a depth of 20 feet; commenced in 1803, opened October, 1820; the first and last of which, together with the Gloucester and Berkeley Canal, may be cited as the first upon which sea-borne vessels could navigate, and thus extend the benefits of ship navigation into the interior of the country, without the delay and expense of transhipment of cargoes until arriving at the warehouses whence they are to be distributed. The Grand Junction (Jessop and Whitworth), Lancaster and Kennet and Avon (Rennie). On the Lancaster navigation the canal is carried across the Lune by a stone viaduct of 5 semi-circular arches, 75 feet span each; the total length of viaduct is 600 feet, and height 55 feet above the river. The Aire and Calder, the Union, the Shrewsbury, New Birmingham and Liverpool, Carlisle, the Grand and Royal Canals, Ireland, amongst many others may be quoted as examples of artificial canals for vessels, so as to enable them to continue their navigation inland from large rivers and estuaries. The total length of canal navigation now in operation in England, Scotland, and Ireland, amounts to about 3,000 miles.

The most advantageous speed for boats on a canal is about 2½ miles per hour, at which rate an average horse is capable of drawing about 22 tons without injuring his physical powers; when this is much exceeded, the ratio of resistance approaches the cube of the velocity. The speed must be diminished in proportion, and the horse exerts his powers to great disadvantage. Large canals, where practicable, on account of the trade and other circumstances, are preferable to small ones, as they are worked more economically. Various contrivances have been made to obviate the necessity of locks in overcoming extensive lifts or declivities, amongst these may be mentioned the inclined planes on the Duke of Bridgewater's and the Tamar and Shrewsbury canals. Double locks, side ponds, hydraulic lifts, by Woodhouse, Salmon, Congreve, Underhill, Green, and others; but extensive reservoirs and feeders are indispensable in most districts where there is a great traffic, and steam engines have been extensively used to pump back the water to be used over again in case of deficiency.

Steam Dredging—The improvement of the River Clyde, begun by Watt and Golborne, received fresh stimulus under Rennie and Telford, from the application of steam power to the dredging-machine by Grimshaw, in 1796, and Bentham in 1802; thus forming a new era in the means of improving river navigation and harbours, since which this important department of engineering has been carried to an extent which could not otherwise have been attempted. Steam-dredging machinery is now generally adopted with success, more particularly in rivers where their beds and channels can be excavated to a certain degree of uniformity, and where the inclination of the tidal and fresh-water currents can be reduced to such an extent, by the removal of obstructions, as will enable them to keep their channels open. As successful examples of this, I need only adduce the Lagan, the Boyne, the Newry, the Liffey, and the Shannon, in Ireland. The Clyde, the Leith, the Don, in Scotland. The Tyne, the Wear, the Tees, the Thames, the Dee, the Ribble, the Severn, and others, in England; and as to harbours, most, if not all, of them can be maintained by steam-dredging, in addition to other means, to a greater depth than could be obtained without such an important aid.

Stone Bridges.

Westminster Bridge, by Labelye, in 1740-47, may be considered the first example of extensive structures of this kind. It consists of 13 semi-circular arches (the centre of which is 75 feet span), 1164 feet long; it was originally intended for a wooden bridge, and was partly commenced on this principle; it was a great work at the time, but as might have been expected, contained defects, particularly in the foundations, which at that time were but imperfectly understood, and have suffered much by the scour of the current; it will probably be rebuilt in a short time. Caissons, or water-tight chests, were first introduced there for the purpose of found-

ing the piers below the level of low water. Previous to this, the principal existing bridges consisted of a number of small Gothic or of circular arches, with rough piers of masonry built either upon a foundation of loose rubble stones thrown promiscuously into the river until sufficiently high and solid, or upon timber platforms resting upon piles surrounded by large bulwarks of timber, filled with loose stones, called starlings, which materially contracted the water-way where they were placed, and by causing increased rapidity in the current, created great obstacles to the navigation, as well as to the drainage of the adjacent country. Of this, the well-known examples of Old London Bridge, those at Newcastle-upon-Tyne, Rochester, and Belfast, may be mentioned. All these, with the exception of Rochester Bridge, are now removed, and are replaced with others constructed upon the modern improved principles. Westminster Bridge was followed by that of Blackfriars by Mylne (1760-71), consisting of nine semi-elliptical arches, the largest of which is 100 feet span and 41 feet 6 inches rise; the total length of the bridge is 995 feet, and 45 feet wide; here the elliptical arch was introduced about the first time in this country. Smeaton's bridges of Coldstream across the Tweed, in 1763, composed of five circular arches, the largest of which is 61 feet span; that over the Tay at Perth, in 1766, of nine circular arches, the largest of which is 75 feet span; at Hexham, over the Tyne, in 1767, of nine circular arches, the largest of which is 52 feet span, and others, for that period, were works of considerable magnitude. These were followed by numerous smaller works all over the kingdom, more remarkable for convenience and utility than for any peculiarity in their construction worthy of notice, until in 1809-1817, when Waterloo Bridge, across the Thames, consisting of nine equal semi-elliptical arches, 120 feet upon each, and 35 feet rise, was built of granite in a style of solidity and magnificence hitherto unknown; there the elliptical arch, with inverted arches between them to counteract the lateral pressure, was carried to a greater extent than in former bridges, and isolated coffer dams upon a great scale in a tidal river, with steam engines for pumping out the water, were, it is believed for the first time, employed in this country; the level line of roadway, which adds so much to the beauty as well as the convenience of the structure, was there adopted. The bridge across the Severn at Gloucester, in 1828, by Telford, is worthy of remark, as being the first with one arch, of 150 feet span, like those of the bridge across the Seine at Neuilly, near Paris, by Perronet, where the interior of the arch is elliptical and the exterior circular.

New London Bridge (1825-1831), consisting of five semi-elliptical arches, viz., two of 130 feet, two of 140 feet, and the centre 152 feet 6 inches span, and 37 feet 6 inches rise, is perhaps the largest elliptical arch ever attempted, the roadway is 52 feet wide. This bridge deserves remark on account of the difficult situation in which it was built, being immediately above the Old Bridge, in a depth of from 25 feet to 30 feet at low water, on a soft alluvial bottom, covered with large loose stones, scoured away by the force of the current from the foundation of the Old Bridge, the whole of which had to be removed by dredging, before the coffer-dams for the piers and abutments could be commenced, otherwise it would have been extremely difficult, if not impracticable, to have made them water-tight; the difficulty was further increased by the Old Bridge being left standing, to accommodate the traffic, whilst the New Bridge was building, and the restricted water-way of the Old Bridge occasioned such an increased velocity of the current, as materially to retard the operations of the New Bridge, and at times the tide threatened to carry away all before it. The great magnitude and extreme flatness of the arches demanded unusual care in the selection of the materials, which were of the finest blue and white granite from Scotland and Devonshire; great accuracy in the workmanship was also indispensable. The piers and abutments stand upon platforms of timber resting upon piles about 20 feet long. The masonry is from 8 feet to 10 feet below the bed of the river.

I will conclude this division of the subject with the celebrated bridge across the Dee at Chester. It consists of a single arch, the segment of a circle 200 feet span, with a versed sine or rise of 42 feet, which is the largest stone arch upon record; the arch stones at the crown are 4 ft. 6 in. deep, and 7 feet at the springing, and the abutments on both sides of the river are founded on new red sandstone. The centre for building the arch was remarkable for its simplicity, strength, and rigidity, by which means the greatest effect was produced by the smallest quantity of timber, and any change of form, so prejudicial in centres, was prevented. This fine structure is due (it is believed) to the combined talents and energies of the late Mr. Harrison, the architect, of Chester, who made the original design; to Mr. George Rennie, who equilibrated the arch, gave the proper dimensions of the voussoirs and form and dimensions of the abutments, the mode of constructing them, and designed the centre, the original model of which is now in our gallery; and to Mr. Jesse Hartley and Mr. Trubshaw, who worked out the details, and carried the whole into effect.

A proper theory of the equilibrium of the arch, which shall satisfy all the conditions of the question, when applied to practice, may be said to be still wanting, though much valuable information may be derived from the scientific works of Hutton, Attwood, Moseley, Gwilt, and others, on the subject.

Oblique or skew bridges have but recently obtained extensive use. Chapman built some in Ireland many years ago, and wrote an account of his mode of constructing them. On railways they were introduced by Stephenson, and are now generally employed. Buck's excellent treatise on the principles and practise of their construction greatly facilitated their execution.

Iron Bridges.

The introduction of cast iron for the construction of bridges commenced about the year 1779, when that over the Severn, near Coalbrook Dale, by Darby, was the first; it consists of a circular arch 100 feet span, and a versed sine of 45 feet, approaching nearly to a semicircle; the height of the springing is 10 feet above low water, and the total height to the underside of the soffit is 55 feet; the banks of the Severn being high, this form accords well with them. It is formed by five ribs of cast iron, with perpendicular spandril pieces, resting upon them to support the roadway. This, for a first attempt, is well adapted to the situation, and has answered the purpose. This was followed by the bridge over the Wear, at Sunderland: the design for this was said originally to have been made by Thomas Paine, the well-known political writer, and was cast at Rotherham, being intended for erection in America; but the materials were subsequently employed in constructing Sunderland Bridge, under the direction of Wilson, in 1796, the idea having been suggested by Rowland Burdon. The curve of the arch is that of a segment of a circle, the length of the chord or span is 200 feet, and the versed sine or rise 30 feet, the total height from low water to the underside of the soffit of the arch is nearly 100 feet. It consists of six ribs, each composed of 105 cast iron radiating pieces, connected at the top and bottom by the circular pieces which form the curve of the arch; these ribs are united in their transverse direction by tie-pieces; the spandrils are filled in with cast iron circles, touching each other at their circumferences, and supporting the roadway, which consists of a strong frame of timber, planked over and covered wtth a cement of tar and chalk, upon which a layer of marl limestone and gravel is placed. The centre deserves notice on account of the difficulty and confined nature of the situation, which rendered it necessary to preserve a constant passage for ships with their standing rigging; this was effected by a perpendicular framing resting upon piles in the bed of the river, with a sufficient opening on each side for the vessels. Upon the top of this perpendicular framing, the transverse framing or centre for supporting the arch was fixed, and answered its purpose well. Some time after the removal of the centre, the arch was observed to swerve bodily in a horizontal direction to the eastward, forming a curve having a versed sine of about 12 or 18 inches; if this had continued to increase, it would no doubt have soon occasioned the downfall of the structure; it was, however, very skilfully remedied by the introduction of transverse and diagonal tie-bars and braces, assisted by wedges and screws, so that ultimately the whole was brought back and secured in its original form and position, where it has since remained in a substantial state without alteration. The width of the bridge is 30 feet; the abutments are of stone, founded on rock; they are 24 feet thick, and from 42 feet to 37 feet wide. This bridge, for boldness of the design and construction, as well as for its elegance and lightness, must be considered a work of peculiar merit; particularly if the period in which it was constructed be remembered.

About the same time, the bridge at Buildwas, across the Severn, by Telford, was erected. It consists of a single arch, segment of a circle, whose chord or span is 130 feet, and versed sine or rise 27 feet, the depth of the iron frame forming the arch being 3 ft. 10 in.; it consists of three ribs, 18 feet wide from out to out, connected together in their transverse direction by tie-bars. The spandrils for supporting the roadway consist of vertical pieces, resting upon the segments forming the arch; the abutments are of stone. There is a novelty in the construction of this bridge worthy of remark. The two outer ribs consist of two segments of circles, each struck from different centres, the crown of one terminating immediately below the roadway, the other at the top of the parapet, so that the platform forming the roadway is both suspended and insistent. The object of this being, it is presumed, to increase the depth of the truss supporting the roadway, and thus to add to the strength of the bridge: but it was unnecessary, and does not appear to have been adopted in any of Telford's subsequent designs, which are numerous. Amongst them may be mentioned that of Bona, Tewkesbury bridge over the Severn, also that over the Dee, near Corwen, &c. Bristol bridge over the Avon, by Jessop, is a neat simple structure. Boston bridge, by Rennie, over the Witham, of 100 feet span, with a versed sine of 4 feet, is remarkable for its boldness and lightness. The principle of construction resembles that of Sunderland, but is an improvement upon it, in having a better system of transverse and diagonal braces, and the spandrils consisting of vertical instead of circular pieces. All these have, however, been far exceeded by the Southwark bridge over the Thames, by Rennie. This consists of three arches, all segments of the same circle; the centre arch is 240 feet span, with a versed sine or rise of 24 feet, and the two side arches are 210 feet span each, with a versed sine or rise of 18 ft. 10 in. each. The arches are formed by eight solid ribs in each, and each rib consisting of fifteen pieces, 6 feet deep at the crown of the arch, increasing to 8 feet deep at the springing, $2\frac{1}{2}$ inches thick in the middle, and $4\frac{1}{4}$ at the top and bottom: these ribs are connected together in their transverse direction by cast iron tie-braces of the same depth as the ribs, but open in the centre, and in the diagonal direction by another series of ribs; the whole of the segmental pieces forming the arch, as well as the transverse and diagonal tie-braces, are kept in their places by dovetailed sockets and long cast iron wedges, so that bolts for holding the several pieces together are unnecessary, although they were used during the construction of the bridge to keep the pieces in ther places until the wedges had been driven. Thus the ribs formed, as it were, a series of hollow masses or voussoirs similar to those of stone; a principle which it is believed is new in the construction of cast iron bridges, but it

has succeeded so well that it is worthy of adoption elsewhere. The spandrils are composed of cast iron diagonal pieces, connected together in a similar manner, and the roadway is formed by solid plates of cast iron resting upon the spandrils, and joined together by iron cement. The piers and abutments are of stone, founded upon timber platforms, resting upon bearing piles, and surrounded by sheathing piles, driven sufficiently deep below the bed of the river. The masonry is tied throughout by vertical and horizontal bond stones, so that the whole acts as one mass in the best position to resist the horizontal thrust. The ribs forming the arches were commenced in the centre, and were continued regularly on each side towards the piers and abutments, upon which a cast iron bed and connecting plate were laid, nicely let into the masonry to receive the ribs forming the arches; when the last segment of each rib was fixed in its place, three cast iron wedges, each 9 feet long and 9 inches wide, were placed behind each rib, and nicely adjusted and fitted to them; these having a very slight taper, were driven simultaneously by heavy hammers, and thus the arches were nearly lifted from the centres, so that the wooden wedges upon which the segment pieces rested were easily removed by a few blows of a hammer; the arches were thus relieved from the centres in a very simple and efficient manner. The whole of the iron-work had been so well put together by Messrs. Walker, of Rotherham, the founders, and the masonry by the contractors, Messrs. Jolliffe and Banks, that when the work was finished, scarcely any sinking was discernible in the arches. During the progress of the work, some experiments were made, in order to ascertain the extent of the expansion and contraction between the extreme range of winter and summer temperature, and upon taking the average of numerous trials by different gauges, it was found that the crown of the arch rose in the summer about an inch to an inch and a half. The work was commenced in 1813, and the bridge was opened in 1819.

Whilst upon the subject of cast iron bridges, we must not omit the Swivel or Turning Bridge. The invention, if it may be so termed, is, it is believed, due to England, and one was first made of iron about the year 1810. They are now almost universally adopted over locks, to the extent of 50 feet span, in preference to the old lifting bridge. Since the introduction of the railway system, cast iron bridges have become very general, and have been particularly serviceable, being formed of girders, where the height was too limited to admit of the arch principle being adopted. Experience of the value of wrought iron in roofs and for other building purposes has induced R. Stephenson to propose that material for constructing the bridge to carry the Chester and Holyhead Railway across the Menai Straits. His design consists of a close wrought iron tunnel or tube, 14 feet wide, 30 feet deep, and 1500 feet long, supported in the middle by a stone pier built upon a rock in the middle of the Straits, with two other piers at the low-water mark on either side, leaving four openings, two of them 460 feet, and two of 230 feet each, and 100 feet above high water, so as to admit of masted vessels sailing under it. Cubitt has also proposed to adopt wrought iron on a great scale, for constructing landing platforms at Liverpool, where the difficulty of building docks or quays, which large steam vessels can approach at all times of tide, render works of this kind necessary to accommodate the immense traffic frequenting Liverpool. The landing platform designed by Cubitt, and now in course of construction, consists of a wooden frame, 500 feet long, by 80 feet wide, floated upon a number of wrought iron pontoons, each 80 feet long, 10 feet wide, and 6 feet deep; it is connected with the shore by two bridges, each formed of two hollow wrought iron beams, 150 feet long, carrying the platform of the bridge; the attachment with the shore and the stage is so made as to admit of motion, both vertically and horizontally, to accommodate itself to the rising, falling, ebbing, and flowing of the tide, which there rises about 30 feet.

Suspension Bridges.

The invention of chain or suspension bridges is said to have been imported from China and India. The first of the kind in England was that across the Tees, at Middleton, consisting of two common chains stretched across the river, and secured to the adjoining rocky banks; the span was 70 feet. To Capt. Sir Samuel Brown, however, who had previously brought chain cables into use for ships, may be attributed the introduction into England of the improved system of the bar link, which is now so generally adopted. Brown, in 1818, first constructed a large model of 100 feet span, capable of supporting a carriage and horses, indeed adapted for general traffic. He afterwards constructed (1819), upon this principle, Union bridge, for general traffic across the Tweed, near Berwick; the span was 450 feet between the supporting towers, which were of masonry. He subsequently built another, of smaller dimensions, across the Tweed, at Dryburg. He also constructed that at Montrose, one over the Hundred Feet river in the Fens, and others, and applied the same principle with effect for landing-piers at Brighton and Leith. This system was afterwards carried out to a far greater extent by Telford, in his great suspension bridge across the Menai, at Bangor, in 1818-20, so well described by Provis. It consists of three openings, the centre is 580 feet span, the deflection of the chain being 42 feet, and the two side openings are 260 feet span each; the platform of the roadway is 100 feet above high-water mark; the sustaining towers of masonry are 50 feet above the roadway, and are connected to the shore by three stone arches on one side, and four on the other, 52 ft. 6 in. span each. There are sixteen main chains, each 1770 feet long, in sets of four each, suspended above each other, on each side of the roadway, which is 30 feet wide from out to out, divided into three parts, two for carriages, on the outside, 12 feet wide each, and one for foot-passengers, in the middle, 6 feet wide. Each main chain consists of five bars or links, 10 feet long each, by 3½ inches and 1¼ inch, connected together by plates and pins, on Brown's system, the whole being properly secured to the solid rock on each side. The total suspended weight of the main opening is 644 tons. About the same time, he constructed another upon the same principles, 300 feet span, across the river Conway, at Conway. These are fine works, and will remain as lasting monuments to his fame. The recent structures of Hammersmith, across the Thames, and Shoreham across the Adour, by Tierney Clark, who is now erecting another upon a grander scale, 700 feet span, across the Danube; and, lastly, that of Brunel across the Thames, at Hungerford Market (1845), show the progress made in this class of structures, which are well adapted for crossing large and deep rivers where economy is an object; great care, however, is necessary in proportioning the strength of the chains, and their curve; the selection and manufacturing of the iron for them, and also in the connexion and bracing of the roadway platform, in order to insure the greatest strength and solidity of construction; of this, the improvements to the Montrose Bridge, by Rendel, is a good example, and the system should be generally followed, as several disastrous failures have occurred from neglect of these important particulars.

Amongst variations of the system, that of Dredge may be mentioned.

The wire suspension system, although in extensive use on the Continent, the largest example of which is at Fribourg, in Switzerland, where a bridge has been constructed of 800 feet span, for carriages as well as foot passengers, has been rarely used in this country. Although economical in the first cost, it requires constant attention, and it scarcely possesses sufficient durability for permanent structures.

Wooden Bridges.

In wooden bridges, little was formerly done in Britain beyond the common pile bridge. These were formed by rows of piles for piers, driven at short distances from each other, and connected together by straight girders planked across to form the roadway, with a wooden railing on each side. Of this kind of construction, the bridges of Londonderry, across the Foyle, Waterford, across the Suir, Battersea, Fulham, and others, across the Thames, are examples. In some cases, this system was extended, by adopting larger openings, having diagonal struts, or butting pieces, between the underside of the girders and the piles forming the piers, in order to reduce the bearing of the girders, and thus give them greater stability. The straight trussed frame or girder, so much used in America, was employed by Rennie, to a considerable extent, as service bridges, during the construction of the Waterloo and Southwark bridges, in 1809-19, and at New London Bridge, in 1823-31, with openings of above 100 feet, capable of supporting the heaviest weights. The late Colonel By, of the Royal Engineers, gave an account of a bridge of this description, said to have been built across the Terrebonne, a large river near Montreal, in Canada, 600 feet span between the piers. It is said that this was carried into effect, and actually stood for a short time; but, in consequence of its having been badly constructed, it required heavy repairs, and whilst these were being effected, the whole structure came down, and was carried away by the floods. The trussed system has been applied with considerable success in some well-constructed bridges across the Tyne, for the Newcastle and Carlisle Railway, by Blackmore, and in several other places. The system of Wiebiking, of combining small curved pieces of timber connected together in the form of an arch, adapted for large spans, was first introduced, I believe, on the Ancholme, in 1826, when a bridge of 100 feet span was constructed with complete success. This has been used by Green, in the viaducts for the Newcastle and North Shields Railway; and has been followed by others also. Price, long ago, proposed a similar system; bnt the scarcity and dearness of timber, and the prevalent use of iron, probably prevented its application before. The lattice bridge, of American origin, has latterly been introduced on the Birmingham and Gloucester Railway, by Moorsom, and on the Dublin and Drogheda Railway by McNeil, and as they are economical and simple in their construction, they are applicable in some cases with advantage.

In the designing and constructing of bridges of stone, wood, cast and wrought iron, an accurate knowledge of the strength of materials is peculiarly important, nay absolutely indispensable; and the profession is much indebted to George Rennie, who commenced a series of investigations on this subject in 1817, which were communicated to the Royal Society, and published in their Transactions in 1818. These experiments were among the first to determine with precision the absolute and relative strengths of materials, under the effects of tension and compression. He subsequently made above six hundred experiments in 1827, on the friction of plane and round surfaces, with and without unguents, under the different circumstances of time, surface, and pressure, which were published in the Philosophical Transactions, in 1828. In 1830 he also made experiments on the friction and resistance of fluids, which were published in 1831. Morin's experiments did not appear until 1834—Tredgold, Barlow, Fairbairn, Hodgkinson, Wood, and others, have since carried these experiments to a greater extent.

Concrete, a mixture of gravel, sand, lime, and other cements, in certain proportions, was well known to the ancients, and in conjunction with the invaluable natural cement, Pozzolana, was applied with the greatest success in the then numerous moles and other submarine works, and its use has been still continued in Italy to the present day. Wren is said to have used it for a portion of the foundation of St. Paul's, where it was defective. Semple also alludes to it in 1776. Its use appears to have been

discontinued for a time, but recently to have been resumed. Rennie proposed it for the foundation of the Penitentiary in 1811; Smirke and others followed in the same track, and now the employment of concrete for the foundations of buildings has become nearly universal, wherever it is necessary.

Brick has been much used for bridges over canals and drains by Rennie, and in railway bridges by Stephenson, Cubitt, Locke, Rastrick, and others; and, latterly, it has been carried to a far greater extent by Brunel in his bridge across the Thames at Maidenhead, for the Great Western Railway. It consists of two semi-elliptical arches, each 130 feet span, and rising 24 feet; they are built wholly of brick, in Roman cement.

Roman Cement, discovered by Parker, in 1796, is chiefly made from a stone found on the shores of the Isle of Sheppy, near Sheerness; it is burnt in a kiln, and when ground into fine powder, possesses the peculiar property of setting hard immediately, although exposed to water, which renders it very valuable in hydraulic works. It had been little used in public works until it was adopted by Rennie and others. It was extensively employed in the naval works at Sheerness and elsewhere, and is now universally employed in buildings where immediate induration or setting is required, in order to prevent the action of water, or where any settlement from insistent weight would be injurious. Latterly Roman cement has been found at Harwich and other places. Aberthaw, Lyme, Barrow and other limestones also possess valuable properties for waterworks. The success of buildings depends materially upon the cement or mortar employed: and much has been done by Smeaton, Rennie, and Telford, in the selection of the best lime, sand, and other materials, in combining them in proper proportions for the respective parts of the works where they were employed, and in the application of machinery for the more thoroughly mixing up and incorporating the materials together. Great credit is also due to Higgins, Pasley, Donaldson, Smith and Godwin for their valuable experiments and treatises upon this important subject.*

Additional strength has been given to brick structures, by the introduction of bands of thin hoop iron between the courses; this improvement was first generally introduced by Sir M. I. Brunel.

Tunnels.

Subterranean tunnels have been much used in inland navigation, particularly in the Duke of Bridgewater's Canal, some miles of which, at Worsley, are made under ground; in the Harecastle Tunnel, by Brindley, on the Trent and Mersey Canal, in 1776, which was rendered more convenient by Telford, in 1826, by adding another parallel to it, of larger dimensions; in the Huddersfield Canal, where there is a tunnel 5280 yards long; in the Braunston Tunnel, on the Grand Junction Canal, and many others: all of these, however, have been surpassed by the Tunnel under the Thames, at Rotherhithe, by Sir Isambard Brunel, which, for magnitude, boldness in the design, and ingenuity in the means of construction, as well as the extraordinary difficulties by which the work was attended, will long remain a lasting monument of the talents and perseverance of that celebrated engineer. This extraordinary work was commenced in 1825; it consists of two arched openings 1200 feet in length, 14 feet span each, 16 feet 4 inches high, separated from each other by a pier 4 feet thick, having sixty-four lateral arches of 4 feet span, to communicate between the main openings, the whole being surrounded with massive walls. The external dimensions of the walls, including the openings, are 38 feet wide, and 22 feet high. It is approached at each end by a perpendicular shaft, 50 feet diameter, and 80 feet deep; but the tunnel was intended hereafter to be carried out to the surface f the adjoining streets, at such a moderate inclination that carriages could easily pass through it from both sides of the river. The crown of the tunnel is about 16 feet below the bed of the river. In order to carry into effect this very difficult work, unusual means and precautions were necessary. The ordinary wooden centre framing scarcely presented sufficient strength and connexion for that purpose. Brunel accordingly invented a cast iron frame (which he termed a shield) sufficiently large to embrace the whole width and height of the intended structure, and divided into thirty-six compartments, each sufficiently large for a man to work in, yet capable of being closed to prevent the access of water when required; the whole was impelled forward by powerful screws, bearing upon the work behind, as it was finished. This ingenious contrivance was perfectly successful; and although the works were twice stopped by the irruption of the Thames, nevertheless the apertures were stopped by bags of clay and other materials, and the structure was continued with extraordinary perseverance until finally completed and opened to the public in 1843. The whole was constructed with bricks set in Roman cement, and cased inside with the same material; and it gives every prospect of permanence and solidity.

A tunnel under the Thames had been previously proposed at Rotherhithe by Trevethick, and had advanced to some distance under the river, when it was abandoned; also one by Dodd at Gravesend, which was scarcely commenced. A tunnel was also carried to a considerable extent under the Severn, at Newnham, but failed for want of funds.

Tunnels form part of the works of almost every considerable railway, and the art of constructing them with accuracy and expedition is now brought to great perfection. Amongst the most remarkable tunnels executed upon railways, may be mentioned that at Kilsby, 2398 yards long, on the Birmingham and London line, by Stephenson; that at Box Hill, 3195 yards long, on the Great Western Railway, by Brunel; and that on the Sheffield and Manchester line, 5280 yards long, by Locke. Several others of great length are now in progress.

Harbours.

In the construction of harbours, Smeaton, as already observed, had pointed out the proper course, in his reports on Lynn, Wells, Aberdeen, Dundee, Dunbar, Port Patrick, Sandwich, Scarborough, Sunderland, Workington, Rye, Dover, and others. Ramsgate harbour was originally designed by Labelye in 1744; it had been partly executed by others, and continued with little success through a tedious succession of years, with various changes of plan, until 1774, when it was placed under Smeaton's direction; he soon saw the evil arising from the constant accumulation of mud which threatened to fill it up, in consequence of there being no back-water or scouring power to remove it. He therefore divided the harbour into two parts by a cross wall; the part next the shore formed a basin of eleven acres, in which the water could be retained by means of a lock, and discharged through powerful sluices in the cross wall into the outer harbour at low water, and thus form an effectual scouring power for removing the mud. Here was the introduction of a new principle for the maintenance of harbours, which is so difficult on an alluvial coast, operated upon by the tides and currents; and although previously in use on the Continent, it is believed to be the first example of the kind in Great Britain. Smeaton afterwards continued the works, and introduced an improved system of masonry; in 1788, he founded the outer and inner walls of the outer piers, below low water, by means of caissons or boxes of wood, and so far improved the diving-bell as to render it useful in carrying on the operations, although he did not build with it, and about the same time he used it for examining the foundations of the piers of Hexham bridge, one of which had partially sunk. The late Mr. Rennie, who after Smeaton's decease took charge of the works at Ramsgate, profiting by what had been done, carried out the system to a greater extent, by enlarging the sluices and making them of cast iron, the old ones being of wood and frequently out of repair; a greater quantity of water could then be discharged in the same time, when required, and thus act with greater effect; or the discharge could be prolonged, according to circumstances. The masonry also, which, although good for the early period at which it was constructed, had become dilapidated, was rebuilt, where requisite, in a much more substantial manner. The steam-dredging machine was also applied to remove that portion of the mud which could not be effected by the sluices. The diving-bell was afterwards perfected by Rennie, so as to be perfectly manageable, and being suspended from a frame worked by proper machinery, it could be raised and lowered, or moved laterally, in any direction, with facility and promptitude, either according to the directions of the diver within the bell, communicated by means of signals, made by striking the sides of the bell with a hammer, or given by the superintendent above. All the operations for preparing a foundation, and afterwards laying the prepared blocks of masonry upon it, could thus be performed with as much certainty below as above the water. Rennie first used his improved apparatus in 1813 for rebuilding the advanced East Pier Head at Ramsgate Harbour, which was founded 17 feet below low water of spring tides with complete success. The value of this invention for submarine operations was now completely established, and he afterwards employed it with advantage in founding the pier heads and outer walls of Holyhead, Howth, and Sheerness Harbours, and other works under his direction, and it is now generally adopted in all similar circumstances. The diving-helmets and dresses, improved by Deane, Bethell, Edwards, Seibe, and others, have also materially contributed to the success of submarine operations.

After Smeaton, numerous artificial harbours were designed and constructed, and natural ones improved; amongst the former may be mentioned Holyhead, Howth, and Kingstown; at the latter there is a depth of 26 feet at low water of spring tides, and an enclosed area of 250 acres at low water; which is the largest harbour attempted in this country by Rennie. Here and at Howth he substituted the flat slope for the upright wall to resist the waves,* and introduced the plan of throwing down loose blocks of rubble, or unhewn stone, for forming the main body of the piers, allowing the slope or angle of repose, at which the materials would lie, to be formed by the sea. In his system of making low-water harbours, which, up to that period, were almost unknown in Great Britain, he adopted the plan of enclosing the area by piers composed of several straight arms or lengths, intersecting each other according to particular angles, instead of making them curved, which, in his opinion, only served to increase the action of the waves. In asylum harbours, when practicable, as at Kingstown, he preferred making the entrance open to the dangerous wind, thus rendering them more accessible for vessels in distress; but in order to prevent the prejudicial effects of any waves which might roll into the harbours, he adopted the returning and inclined form of entrance, by which means increased facility of entrance and departure was also given. He also designed his harbours with a view to preserving the original depth, as far as practicable, which is a principle of the greatest importance, and ought not to be lost sight of. The artificial harbours

* From the valuable researches of these authors it appears, that the hydraulic cements contain considerable portions of silica and alumina, and in some cases metalic oxides; and, where natural hydraulic cements cannot be obtained, they may be produced artificially, by the combination of these ingredients in their proper proportions.

* This system was latterly always adopted by Rennie and Telford in preference to the upright wall, as being better adapted to resist waves, and it has been invariably successful, wherever it has been properly carried into effect.

of Ardrossan, the Troon, Peterhead, by Telford, Scarborough, by Chapman, Hartepool, and others, are worthy of remark.

In the improvement of natural harbours, may be mentioned Sunderland, Berwick, Aberdeen, Dublin, Newry, Drogheda, Leith, Belfast, and others. The principle generally adopted has been to confine and direct the tidal and fresh waters, by piers, in proper and sufficient channels, whence they are discharged into the ocean, so as to enable them to act with greater effect in counteracting the baneful effects of the antagonist operations of the winds, waves, and sand, brought in from the sea; also to increase, as far as practicable, the receptacle for tidal and fresh waters, and to dispose of them in such a manner that they shall act with effect in maintaining and preserving the channels. These operations, as in the case of the Clyde, are materially assisted by the employment of that invaluable auxiliary, the steam-dredging machine, which ought to be attached to every harbour. I must not omit to mention the breakwater in Plymouth Sound, by Rennie and Whidbey, which is the first and largest example of a detached mole or breakwater in this country. It is a mile long, constructed in a depth varying from 5 to 8 fathoms at low water, formed of loose blocks of rubble, of all sizes, up to 10 or 12 tons weight each, thrown into the sea to form their own base and slope, according to the action of the waves. The surface from low water mark to its full height, which is 2 feet above high water, has been paved with masonry, and at the base of the sea slope, at the level of low-water, there is a berm or benching to protect it. At the western extremity a light-house has been built, to point out the western or principal entrance to the Sound, and a beacon on the eastern extremity points out the east entrance. The whole of the work, except a portion of the masonry, which is granite, has been built of limestone, brought from the adjoining shores. The intention of the work was to protect the Sound against the heavy swell, which formerly used to roll in with considerable violence during strong westerly and south-westerly gales; this object has been completely obtained, and the roadstead has been rendered perfectly secure. The work has been eminently successful in every respect, for besides obtaining the desired protection, the original depth of water has been preserved, the facility of ingress and egress has not been diminished, but rather increased, and the cost has corresponded as nearly as possible with the original estimate.

Another class of harbours, called Floating or Wet Docks, for receiving merchant vessels out of the tide or sea-way, was first introduced at Liverpool about the year 1716, and wet docks have been since constructed in almost all the principal ports of the kingdom—viz., London, Bristol, Hull, Leith, Sunderland, as well as for the Royal Navy at Portsmouth, Plymouth, Sheerness, Chatham, and Woolwich. The East and West India Docks, by Jessop, Rennie, and Ralph Walker; the London, Leith, and Dublin, by Rennie; St. Catherine's, London, by Telford; the New Docks at Liverpool, by Hartley; at Hull, by James Walker; at Cardiff, by Cubitt; at Newport, by Green; at Southampton, by Giles; and the great works now in progress at Birkenhead, on the Mersey, opposite Liverpool, and at Great Grimsby, by Rendel, are magnificent examples of private enterprise for facilitating the commerce of the empire. The design of Rennie for a grand naval arsenal on the Thames, at Northfleet, immediately above Gravesend, intended as a substitute for the imperfect naval establishments at Deptford, Woolwich, Sheerness, and Chatham, is worthy of remark. This magnificent design consisted of six capacious basins, with a total surface of 600 acres within the walls, the largest being 4000 feet long, and 1000 feet wide, and covering 87 acres; the whole to communicate with each other, and be provided with capacious quays, dry docks, building-slips, and storehouses; steam machinery for manufacturing cordage, blocks, anchors, flour, and bread, sawing and converting timber, pumping, and working cranes; in fact, for almost every operation connected with the naval service, and so systematically arranged and disposed, that the required operations should succeed each other with the greatest dispatch and economy, whether of time, labour, or cost. The estimate was £11,000,000, which was perhaps more than would have been required: any portion could have been executed as it was wanted, without interfering with the general plan. It is to be regretted that this plan was not carried into effect, for it would have repaid the cost in the increased economy of fitting out fleets, and since that period about £5,000,000 have been expended on the old establishments in the Thames and Medway, with a small degree of benefit, compared with what would have been obtained from Northfleet. His design also for the improvement and enlargement of Chatham Dockyard is worthy of remark. It consisted of a new channel to be made for the Medway below Rochester Bridge, and converting the bend of the river, in front of the Dockyard, into a magnificent floating dock of above 100 acres, and from thence making a canal, 1¼ mile long, 300 feet wide, and 30 feet deep, to the deep water in the Medway at Gillingham, by which means vessels of war of the largest class could come to the Dockyard with the whole of their armament, which they cannot do now; the course to sea would have been shortened, and the shallow water of the Medway avoided: thus Chatham Dockyard would have been rendered the most convenient and extensive in Europe, and its proximity to London by a railway would have rendered the yards at Deptford and Woolwich unnecessary. The estimate for this work was only £700,000, whereas since that time fully as much, if not more, has been spent upon Woolwich, with a very inferior result; indeed, it is not even too late to undertake this plan for Chatham now, and would well repay the expenditure. In designing and carrying into effect this important class of public works, so as to render them successful, a thorough knowledge of the nature and operation of tides, winds, currents, soundings, and all the departments of hydrography, physical geography, and geology is necessary, and in these sciences much is due to the exertions of Beaufort, Bullock, Washington, Denham, Buckland De la Bèche, Lyell, Greenough, Sedgwick, Murchison, Phillips, and others.

Revetments, or Retaining Walls.

These, until near the latter end of the last century, had been usually built with horizontal foundations and courses, the interior side being almost vertical, and the exterior with a flat face and very little batter, or in many cases vertical. The curved face retaining wall was latterly introduced, with the foundation and courses inclining from the horizontal, so as to conform with the radius of curvature; this form of wall is preferable, in many cases, to the old, as combining greater strength with a less section, and being more convenient in other respects, and was commonly used by Rennie in his various works, when applicable.

To whom the introduction of this improved form of wall is due it is difficult to ascertain with accuracy; but Rennie, Ralph Walker, and Jessop were amongst the first who brought it into use. A further improvement was made in the retaining walls used at Sheerness in 1815 by Rennie, where the foundation being composed of soft alluvial mud and quicksand, to a great depth, more than usual precautions were necessary to render the walls substantial and secure. The object was effected by enlarging the base, and making the interior hollow, like a caisson, with the bottom in the form of an inverted dome; the outer or river face being concave, and the foundation, for a certain width, laid inclining at right angles to a tangent from the curved face of the front of the wall; the remainder of the foundation was horizontal, and the back or land side of the wall was vertical. Thus there was both a front and back wall connected together by cross walls, forming one mass; the inverted arches or domes under the hollow spaces being filled with chalk and gravel concrete, and the whole resting upon a well-connected platform of piles and cross-beams and planking. By thus distributing the same quantity of materials over a greater surface, the vertical weight per square foot was reduced, and the desired stability was obtained upon this very difficult and treacherous foundation. Rennie had previously tried, with success, a wall of a similar principle, and under similar circumstances at Grimsby. General Bentham also tried a similar principle, about the same time, which was not so successful, in consequence of an unsuitable form and construction.

The *Coffer-dams* which Rennie employed for constructing the walls at Sheerness are worthy of remark, as being the most extensive and difficult that had been constructed up to that period. The bottom being soft mud to a considerable depth, piles of 60 feet to 80 feet in length, were necessary, and when driven and braced in their places as far as practicable, chain bars and raking-shores from the land were requisite, in order to counteract the alternate pressure inwards and falling outwards, occasioned by the badness of the foundation and the heavy shocks of the waves to which they were exposed. In order to break the effects of the sea during storms, he employed a series of old men-of-war hulks, to act as floating breakwaters; these were useful to a certain extent, so long as they held firm in their places; but at times, during heavy gales, they dragged their moorings, and driving against the dams, occasioned considerable damage; upon the whole, however, they were useful.* In order to give greater security to the dams, and to prevent leakage, a considerable quantity of grooved and tongued sheathing-piles were necessary for the works; and to effect this, he invented a machine worked by a steam engine, which answered the purpose effectually, at a cost of one-sixth of the price of manual labour, and as it was unsafe to withdraw any of the coffer-dam piles, he made another for cutting them off at the ground level, below low water, which was also found very useful.

The dams for founding the sea-locks of the Caledonian Canal at Fort William and near Inverness, by Telford, are worthy of remark. In the former case, great difficulties arose, in consequence of the foundation being rock, at some depth below low water; this was overcome by ingeniously securing the piles to the rock; and in the latter case, where the bottom was soft mud, the difficulty was obviated by bringing cargoes or masses of earth and clay from a considerable distance, and afterwards driving the piles through the made ground. The great dam, 1000 feet in length, for building the foundations of the river-wall and New Houses of Parliament, by James Walker, is another good example. The late Peter Ewart was among the first who introduced cast and wrought iron for dams, for piling in general, and for wharfs; it has been since employed by Walker, Sibley, Stevenson, and others, in many situations, with great success. At the Albion Mills, already mentioned as the first steam-mill constructed in 1785, by Watt and Rennie, on the banks of the Thames, close to Blackfriars Bridge, the foundation being soft mud and moving sand, inverted arches were formed upon the ground, between the foundation courses of the walls, so that the whole area of the building obtained support by the same weight resting upon an increased base.

* Floating breakwaters of timber have latterly been tried, as a substitut for more solid constructions, but they have not hitherto succeeded.

(To be continued.)

REGISTER OF NEW PATENTS.

ELECTRIC TELEGRAPHS.

John Nott, of the city of Cork, gentleman, for "*certain Improvements in the means of communicating intelligence from one place to another.*"—Granted January 20; Enrolled July 20, 1846.—*(Reported in Newton's London Journal.)* *With Engravings, Plate VI.*

These improvements in the means of communicating intelligence from one place to another consist in certain novel arrangements of apparatus, by which audible and visible signals can be given through the agency of electro-magnetism.

In Plate VI, fig. 1 represents the external appearance of the apparatus, as seen in front; fig. 2 is a vertical section, taken transversely through the apparatus, nearly at its centre; fig. 3 represents the internal construction and arrangement of the working parts of the apparatus, as they would appear if the dial-plate and front part of the case were removed; and fig. 4 is a horizontal section of the apparatus, taken below the magnets, showing the mechanism by which the course of the electric fluid may be changed from the electric telegraph to the signal-bell.

In the front of the box or case, a circular dial-plate, fig. 1, is fixed, on which are four series of letters, which are pointed out by the long arm of the index; and also two concentric circles of numerals, indicated by the short arm of the index. This plate is graduated on its face into ninety-six equal divisions, formed in a circle; and to each, one of the letters or one of the numerals refers. Upon the outer end of an arbor *a*, passing through the centre of the dial-plate, a index *b*, is affixed, which is carried round upon the face of the dial-plate by successive actions of the mechanism, produced by the electric fluid; each successive action moving the index over one space of the graduated circle, so as to enable the operator to leave the point of the index in a state of rest, opposite to any letter or numeral, as the case may be; and, by repetitions of the like movements and rests, to point to such letters as will spell, or numbers that will indicate, the word required to be communicated. These actions of the mechanism are effected by currents of electricity, through the agency of a key or lever, rising or falling at the touch of the operator, as in a piano-forte.

The electric fluid is derived from a galvanic battery near the apparatus, as at A, B, fig. 4, and passes, by wires coiled round electro-magnets, from one pole to the other pole of the battery. Two electro-magnets, C, C, D, D, are attached to the vertical backboard *c*, *c*, of the apparatus, as shown in figs. 2 and 3; and in the same plane, nearly concentric with these magnets, is a ratchet-wheel *d*, fixed upon the arbor *a*; which latter passes through the centre of the dial-plate, and carries the hand or index *b*. Two lever armatures *e*, *e*, are supported by fulcrum axles, turning in the brackets *f*, *f*, which armatures cross each other, and their movements are rendered simultaneous by a connecting link *g*, immediately over the axis of the ratchet-wheel *d*. To the extremities of the inner arms of these lever armatures two pallets *h*, *h*, are connected, by joints; which pallets are pressed against the periphery of the ratchet-wheel by delicate springs, causing the pallets to take into the teeth of the ratchet-wheel; and, by the rising and falling of the armatures, these pallets move the ratchet-wheel round;—the extent of action of the pallets being limited by two latch-stops *i*, *j*, which give rise to a dead-beat movement of the index, as it is carried round the dial-plate. The outer extremities of the armatures bear upon slight springs *k*, *k*, fixed to the back-board of the instrument.

A third electro-magnet E, E, is affixed to the back-board, figs. 2 and 3, and is intended to give motion to the machinery of the signal-bell, attached to the telegraph. The armature of this magnet is shown at *l*, *l*, and is a T-formed lever, supported at the extremities of the edge of its longitudinal bar by pivots, bearing in the brackets *m*, *m*, projecting from the back-board. The arm of this lever *l*, passes through an opening in the back-board, and lies inclined, as shown in fig. 2. When this armature is attracted by the magnet, it will be drawn up into a horizontal position, and, in rising, the extremity of the arm will take into the fork at the end of the lever *n*, and thus cause the hammer *p**, to strike upon the bell or gong F.

The means by which the electric fluid is conducted from the battery, through the wires of the electro-magnets, to the corresponding apparatus at the distant station will be clearly understood by the following description:—Two wooden cylinders G, H, are supported on horizontal axles, by standards fixed to the longitudinal support I, I. Two separate strips of metal, as conductors, are passed nearly round the circumference of each of these cylinders, leaving unoccupied a conducting portion on each cylinder between the ends of the strips. Upon the support I, I, eight erect springs 1, 2, 3, 4, 5, 6, 7, 8, are fixed; which springs severally press against the peripheries of the cylinders G, and H. The springs 2 and 3, are connected by a conducting strip of metal, fig. 4, and the springs 6 and 7, are also connected in like manner; the latter being perfectly detached or insulated from the former. A wire 9, connected with the pole A, of the battery, leads to the stud K, where it is held fast by a binding screw; and to this stud K, the end of another wire 10, is soldered, which passes under, and is attached to the operating finger-key J, and, bending down, terminates immediately over a cup of mercury 11, best seen in fig. 2. The end of a wire 12, is soldered to the erect spring 6, and is brought round into communication with the mercury in the cup 11. On the key J, being depressed by the finger of the operator, the pendent end of the wire 10, will be brought into contact with the mercury in the cup 11, when the electric fluid from the battery A, will be instantly conducted from the pole A of the battery, through the wires 9, 10, 12, to the spring 6, and from the spring 6, through its connection (fig. 4), to the spring 7, and thence over the band on the cylinder H, to the spring S, and from that spring, by a wire 13, to one pole of the electro-magnet C, as shown in fig. 3. The electric fluid will then pass through the coils of this magnet C, and thence, by a wire, to one pole of the magnet D, and, proceeding through the coils of this magnet D, will then descend from its other pole by the wire 14, to the stud L, fig. 4; to the under part of which stud it is soldered. Another wire 15, is attached to this stud L, by a binding screw, from which it proceeds to the telegraph at the distant station, and the current of electricity is by that means conducted through the electro-magnets of such distant telegraph, which is precisely similar in construction to the apparatus above described. The electric fluid having passed through this course returns from the distant telegraph by the wire 16, to the stud M, fig. 4; which wire is secured thereto by a binding screw. Another wire 17, soldered to the under part of this stud M, conducts the electric fluid to the erect spring 4, from whence it proceeds over the band on the cylinder H to the erect spring 3, and from that spring by a wire 18, to the stud N; from the binding screw of which another wire 19, soldered or connected to the under part of this stud N, leads the current of electricity to the other pole B, of the battery, and thus the electric circuit is completed.

It will now be seen, that when the finger of the operator depresses the key J, the pendent end of the wire 10, being thereby brought into contact with the cup of mercury 11, will cause the electric fluid from the battery to pass through the circuit as described. The electric fluid, in proceeding through the coils of the electro-magnets C, and D, develops an attractive force, which, acting upon the lever armatures *e*, *e*, attracts the arms of those levers toward the poles of the magnets, and, in so doing, raises the pallets *h*, *h*; one of which then moves the ratchet wheel *d*, and with it the arbor *a*, and index-hand *b*, through a space equal to one division of the circumference of the dial-plate. On raising the finger from the key J, the wire 10, is withdrawn from the mercury cup 11, and the circuit of electricity becoming thereby broken, all the parts will fall into their original position, as shown in fig. 3; and the other pallet will move the ratchet, and thereby cause the index-hand to pass over another space or division of the dial. A repetition of the touch upon the key J, produces the same effect as described, and moves the index-hand through another space or division of the dial-plate, and so on,—the operator resting when the hand *b*, arrives at any letter or number upon the dial which he wishes to have noted; and by a succession of these movements and rests, the letters or symbols of any desired word or words may be indicated at the distant station.

In commencing the telegraphic communications, it is desirable, in the first place, to indicate whence it proceeds, which may be done by giving one, two, three, or any other conventional number of strokes on the signal-bell. In order to effect this at the remote station, a current of electricity is conducted in the way above described; but a slight change in the positions of the cylinder G, H, of the apparatus is first made.

It has been already stated, that the wooden cylinders G, and H, have metallic conducting bands placed partially round them; which bands leave non-conducting portions on the periphery of the wooden cylinders. It is by means of these that the operator is enabled to change the current of the electric fluid from the telegraph to the bell, and *vice versâ*, by a simple movement. At figs. 3 and 4, (which represent the conducting wires in connection with the telegraph) it will be seen that the erect springs 1, and 5, bear against those parts of the cylinder G, over which the metallic bands do not extend,—consequently those springs are at this time insulated; but if the cylinders G, H, were turned round simultaneously about a quarter of a revolution, the metallic bands of the cylinder G, would be brought into connection with the springs 1, and 5; and at the same time the springs 4, and 8, would become insulated, by having the non-conducting parts of the cylinder H, brought into contact with them. This is effected by the movement of a sliding-bar P, in front of the apparatus, shown at fig. 1; which bar is attached to parallel levers *p*, *p*, fixed upon the outer end of the axles of the cylinders G, H; and at the centre of the bar is an erect index *q*. If the bar is slidden toward the left, as shown in the figure, its index *q*, will point to the mark T, (referring to "telegraph,") and the cylinders will be situate as shown at fig. 3; the apparatus being then in a position to communicate with the telegraph. But if the bar P be slidden to the right, so that the index *q*, points to the mark B, referring to the "bell," then the cylinders G, H, will be turned round about a quarter of a rotation; by which means the conducting bands of the cylinder G, will be brought into contact with the springs 1, 5, and the bands of the cylinder H, will be withdrawn or insulated from the springs 4 and 8. When the cylinders G, H, have been thus turned round, the electric fluid will be conducted through the magnet E, E, instead of following the course previously described.

The finger of the operator being now applied to the key J, the electric fluid will pass from the pole A, of the battery, by the wires 9, 10, and 12, to the spring 6, and thence, passing over the band of the cylinder G, will proceed through the conducting spring 5, and wire 20, up to one pole of the magnet E, E. The electric current will now pass through the coils of the magnet E, E, and decend by a wire 21, leading from the opposite pole of the maguet; which wire is connected to the wire 14, which is soldered to the stud L, as previously mentioned and shown at fig. 4. This causes the electric fluid to pass from the stud L, through the wire 15, to the distant telegraph, and return again by the wire 15, to the stud M, as before

explained. This position of the cylinders G, and H, being such as to carry the electric fluid through the coils of the electric magnet E, the lever armature *l*, will be drawn up into a horizontal position, and in so doing will cause the hammer *p**, to strike the gong or bell F.

The patentee next describes certain appendages which he proposes to adapt to the electric telegraph. Firstly, of a commutator, or pole changer, for reversing the direction of motion of the electric current; secondly, of a rheopeter, for changing the direction simply of the electric current; these being for the purpose of separating any number of intermediate stations from the telegraphic circuit, or of connecting any of those stations with the circuit, when desired. Fig. 5 is a front elevation of the commutator, and fig. 6 a top view of the same. A, is a block of wood, and B a wooden cylinder, turning upon an axle mounted in standards. Upon the periphery of this cylinder seven strips of copper are arranged, as shown in fig. 7, which represents the periphery of the cylinder B, extended in a plane. One of these strips of copper, *a*, is imbedded transversely in the periphery of the cylinder; the other six strips, *b c d* and *e* are also imbedded, and extend partially round the periphery of the cylinder. These latter strips are intended to reverse the direction of motion of the electric current: the strips d^1 and e^1 are directly connected by two wires with *b* and *c*; and the strips *d* and *e* are alternately connected with *b* and *c*, by two wires crossing each other, one of which, *f*, forms a communication between *b* and *e*; and the other wire *g*, between *b* and *d*. These wires, *f* and *g*, are insulated from each other, and deeply imbedded into the cylinder, and they are covered by a transverse piece of ivory *h*. Four erect springs, *i k l* and *m*, are affixed to the base block A; their upper parts pressing against the periphery of the cylinder. A handle *n* is affixed to the axle, for the purpose of turning the cylinder round; and an elongation of the handle forms a pointer, to indicate the extent to which the cylinder is to be moved. A wire is attached to each of the springs, for the purpose of connecting this instrument with the electric circuit; and by turning the cylinder to the right or left, the direction of the electric current may be changed, or, in other words, the poles of the battery may be reversed.

The rheopeter is shown in horizontal view at fig. 8, and in vertical section at fig. 9. A, is a circular block of wood, in which two permanent magnets are imbedded; their poles extending upwards, as at N, S, N*, S*. *x y z*, are three glass cups containing mercury. *a a*, is a bar of soft iron, supported in a horizontal position by the vertical pin *b*; round this bar an insulated copper wire *c c* is coiled, the ends of which extend at right angles to the bar, and are bent down so as to touch the surface of the mercury in the cups. A wire *d*, being supposed to communicate a current of electricity (say from London) to the mercury in the cup *x*, that electric current will be conducted by the wire *c*, to the mercury in the cup *y*, and from thence pass on by the wire *e*, to the place of its destination (say Rugby), and thence through the remainder of the telegraphic circuit, back again to its starting point. As the electric fluid thus passes, the bar *a* becomes magnetised, and its ends are attracted by the poles of the permanent magnets, S and N*, as shown at fig. 8. If, for example, the current of electricity is required to be cut off from the telegraph at Rugby, and directed, say towards Birmingham, the poles of the battery are changed, by means of the apparatus shown at fig. 5. The direction of motion of the electric current being thus reversed, it will, in passing through the wire *d* (figs. 8 and 9), cause the ends of the bar *a* to be attracted by the reverse ends of the magnets, that is, N and S*; by which means the pendent end of the wire *c* will be brought from the mercury cup *y*, to the mercury cup *z*, and the current will then, instead of proceeding through the wire *e*, as before, take its course through the wire *f*, and so on, to Birmingham; by which means the telegraph at the Rugby station is effectually thrown out of the circuit.

When the circuit of the telegraphic apparatus is required to be closed, the key J, fig. 1, must be depressed. In order to keep the circuit closed, the draw-stop Q Q is pulled out, which draws down a small lever R, into the position shown by dots in fig. 2. This lever R, keeps the key in a depressed position, and the instrument is thereby prepared for receiving communications from a distant telegraph.

At figs. 10 and 11, a modification of this rheopeter is shown, in which the electro-magnet is made to move in a vertical instead of a horizontal plane. The advantage consists in the facility which it affords of changing the local direction of the electric current, without interrupting the current itself in so doing. This results from the manner in which the wire of the electro-magnet is coiled. Upon each half of the soft iron bar there is a separate coil of insulated wire; the length of the wire of each of these coils proceeds from the extremity of the bar to its middle, and then returns, by overlapping, to the same extremity of the bar where the ends of the wire, forming the coil, are made to dip into mercury cups. By this arrangement, one of these coils is dextrorsum, and the other sinistrorsum relatively to the side of the bar at which the electric current enters the coil. Then, if the electric current be supposed to branch off in two different directions, and pass from the same side of the bar, through these two coils simultaneously, the electric current would flow in the same direction through both coils, and, consequently, the polar unity of the resulting electro-magnet would be preserved. It is therefore obvious, that when the electric current enters either coil from the same side of the bar, a similar polarity results, and a corresponding motion is communicated to the bar, by the influence of the permanent magnets, as will be subsequently described; and when the electric current enters either coil from the opposite side of the bar, the polarity, and, consequently, the motion of the bar, is thereby reversed. In these alternating motions, when the bar becomes horizontal, as seen in the drawing, the ends of the two coils are immersed in the mercury cups, and therefore, without interrupting the electric current, its local direction may be changed, by depressing either end of the bar, as will be seen by the following description of the several parts of the instrument.

Fig. 10 is a plan view of the instrument, and fig. 11 is a vertical section. A is a block of wood, forming the base, and N^1 S^1 N S two permanent magnets, having their similar poles opposite in the same vertical plane, and fixed to the base A by brass clamps C C. D D, are two brass standards, screwed to the base, and carrying set screws with sunken centres, which form the bearing-points of the horizontal axle E, which passes through the soft iron bar F. Round one-half of this bar a double coil G of insulated wire is wound; and the ends of this wire dip into the mercury cups H and I. Round the other half of this said bar there is a similar coil K of wire, the ends of which dip into the mercury cups L and M. The two mercury cups L and H at the same side of the bar, are both connected by the wires P^1 P with the stud O, to which the main circuit wire V, is fastened by a binding screw. The mercury cup M is connected by the wire S with the stud T, to which, by a binding screw, the current-entering wire U of the telegraph is fastened. The mercury cup I is connected by the wire Q, with the stud R, which latter is connected by the small branch wire W, with the current-issuing wire of the telegraph, which passes to the remote terminus. Now, for example, suppose the electric current to be passing from the stud O, to the mercury cup L, it will then pass through the coil of wire K, to the mercury cup M, and so on through the current-entering wire U, of the telegraph. The electric current now passing through a sinistrorsum coil, the extremity Y of the iron bar becomes a north pole, and the other, Z, a south pole. This extremity Y, of the bar is then repelled by the pole N^1 of the permanent magnet, attracted by the pole S^1; it therefore descends, and releases the ends of the coil G, from the mercury cups H and I. The telegraph isthen within the electric circuit.

If the direction of motion of the electric current be now changed, the current-entering wire U becomes the current-issuing wire, and the stud R is now connected with the current-entering wire. The electric current then passes from the stud T, to the mercury cup M, and thence through the coil K, to the mercury cup L, and so on to the main wire V. As the electric current, in this case, passes through the coil K, from the opposite side of the bar, this said coil is thus rendered dextrorsum; the polarity of the iron bar is therefore changed, the end Z becoming a north pole, and the end Y a south pole. This end Y of the bar is therefore repelled by the pole S^1 of the permanent magnet, and attracted by the pole N^1. The extremity Y of the bar is therefore raised from its inclined position, as in the first instance, and releases the ends of the coil K, from the mercury cups L and M, at the same time that its other extremity, being depressed, immerses the ends of the coil G, in the mercury cups H and I, and this immersion takes place before the ends of the coil K leave the mercury cups L and M.

As the stud R is now externally to the telegraph connected with the current-entering wire, the electric current, instead of passing through the telegraph, branches off to the stud R; it then passes to the mercury cup I, thence through the coil G, to the mercury cup H, and so on to the main wire V. The telegraph is thus, without any interruption of the electric current taking place, put out of the circuit; and as the electric current now passes through a sinistrorsum coil, the bar retains its position, until the direction of motion of the electric current is reversed, to bring the telegraph again within the circuit.

Fig. 12 represents, in elevation, one of the posts for supporting the circuit wires of the telegraph along the line of communication. This post is of wood, and is to be sunk about five feet into the earth, the sunken portion being imbedded in Roman cement. A wooden lantern-shaped box completely covers about 16 inches of the upper end of the post, so as to protect this portion of the post (which is to be well varnished) from the humidity of the atmosphere. The box is made in two parts; the cover is of a pyramidical form, and is firmly fixed on the post; the case is made to slide up and down upon the post, and is fastened to the cover, so as to completely envelope the varnished portion of the post, and the broad binding screw clamps thereon, which carry the telegraphic wires. No metal whatever is used in the construction of this box, to the outside of which an insulated lightning conductor, passing down to the earth, is attached.

The patentee claims, Firstly,—the construction and use of the direct action electro-magnetic telegraph, as before described; and particularly the arrangement of the letters or symbols on the dial plate; and the means applied to communicate direct circulate motion to the ratchet-wheel, and the index, by the alternate motion of two jointed lever armatures, working simultaneously, by being connected with one another, in the prolongation of the vertical diameter of the wheel; the pendent portions of these lever armatures forming the pallets of the escapement, and taking into the teeth of the ratchet-wheel; their ascending and descending motions being regulated by the latch-stops, which produce a dead beat escapement; he also claims this escapement, whether it be worked by two levers, as described, or by one lever only. Secondly,—the adaptation of the electro-magnets of the telegraph, as before described and represented in the drawings, whereby they form what may be called a magnetic circle, and attract the extreme and mediate ends of the armatures simultaneously, when the electric circuit is closed; and by the proximity of the bell-electro-magnet and

its armature, one edge of which is always in contact with the poles of the said magnet, the reactive force of electrical induction is brought to bear so as instantly to destroy the attractive force of the electro-magnets of the telegraph, as soon as the electric circuit is opened. Thirdly,—the arrangement of the machinery of the signal-bell of the telegraph, as before described. Fourthly,—the means employed for throwing the telegraph out of the electric circuit, and bringing the striking machinery of the bell into the electric circuit, and *vice versâ*; and also of permanently closing the said circuit by means of a lever and draw-stop. Fifthly,—the means of communicating with all the stations simultaneously, or throwing any of the said stations out of communication, at pleasure, by the employment of the commutator and rheopeter, as hereinbefore described. And, Lastly, he claims the said improvements, however they may be varied in their constructive details, so long as the general arrangement of parts, as above set forth, is retained.

STEAM ENGINE REGULATOR.

MOSES POOLE, of London, gentleman, for "*Improvements in regulating the velocity of steam engines.*"—Granted June 29; Enrolled December 29, 1846. (*With Engraving, Plate VI.*)

The improvements relate to an apparatus to be used in connection with a governor of a steam engine; firstly, to the mode of employing the power of compressed air forced into a chamber by means of a double-beat valve-pump, worked by the engine, so that the air in the chamber may be kept in a more or less compressed state according to the resistance of the engine; the piston-rod of the piston, which is acted upon by the compressed air, communicates with a valve, to regulate the opening of the throttle-valve, through which the steam passes to the steam-cylinder, by which the engine is kept in a uniform state, whatever be its variation. Secondly, to the application of another apparatus similar to the one hereinbefore described, the difference of which consists in using the pressure of the atmosphere acting upon a piston, to press it into a vacuum in place of compressed air; so that the same apparatus, by reversing the action of the valves (causing them to open outwards, instead of inwards) might be used practically for either purpose.

The engraving, Plate VI., shows a vertical section of the apparatus; *a* is the air pump with piston, worked by a rod connected with the driving shaft; *b*, *b*, *b*, valves opening inwards, at top and bottom of the cylinder; *c*, *c*, wind-bores or ports with valve-beat; *d*, condensed air passage; *e*, condensed air cylinder; *f*, pressure piston; *g*, piston-rod, passing up through the conical standard *h*, to lift a counter-balance weight *i*, which is connected with the throttle-valve of the steam-pipe; *j* is a small regulating valve, and *m* a regulating tube, with a regulating cock *n*, worked by the action of the governor *o*, through the intermediate rod and lever *p*.

The apparatus is worked in the following manner: the driving-shaft of the engine gives motion to the piston of the air-pump *a*, and at each upward and downward stroke forces, through the ports *c*, *c*, compressed air into the condensed air passage *d*, and lifts the piston of the small cylinder *e*, together with the weight *h*, which is kept suspended by the elastic power of the air. If the air be condensed too highly, it is enabled to escape through the valve-plug *j*. When there is any deviation in the speed of the engine, the governor immediately corrects by allowing part of the condensed air to escape through the regulating cock *n*, and causes the piston *f* and balance-weight *i* to be slowed, and through the latter the throttle-valve is acted upon.

By the combination of the air pump with the governor, the patentee states that the steam way of the engine is capable of being regulated to a greater nicety.

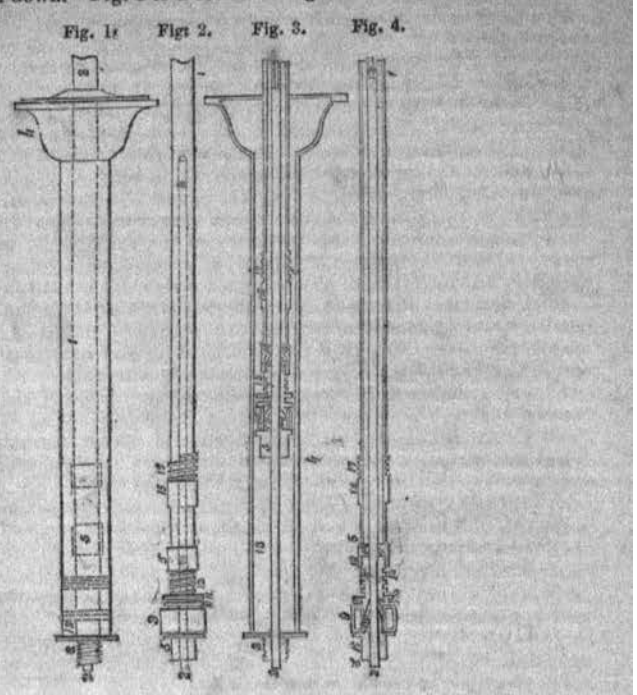
CHANDELIER SUSPENDERS.

JOHN FINLAY, of Glasgow, ironmonger, for "*Improvements in raising and lowering Gas and other Lamps, Lustres, and Chandeliers.*"—Granted February 18; Enrolled August 18, 1846.

This invention consists of a method of supporting, by atmospheric pressure, such gas and other lamps, lustres, and chandeliers, as require to be raised or lowered, in the following manner:—

There is to be attached to the ceiling of the room from which the chandelier is to be suspended a rod, carrying at its lower end a piston, constructed in the manner hereinafter described. The chandelier to be suspended is connected to a tube, which is made to slide air-tight on the said piston. A vacuum being produced in the tube beneath the piston, as hereinafter particularly described, the pressure of the atmosphere supports the said chandelier; the area of the piston, and diameter of the tube in which it slides, are proportioned to the weight of the chandelier to be supported.

Fig. 1 is an outside view of a gas lamp slide, of 1½ inch diameter, inside measure, consisting of a gas tube, attached to the ceiling of the room, from which the lamp is suspended, by means of atmospheric pressure being brought into operation by means of a vacuum in the cylinder at 13, on the under side of the piston, 5; the position of the piston and of the tube are denoted by the dotted lines. 3 is a screw for attaching the slide to the lustre, the weight of which should be about twelve pounds. 2 is a tube placed within the roof tube 1, which conveys the gas to the arms of the lamp, and is made fast at the screw 3. Fig. 2 is an outside view of the roof tube, with the piston, 5, ont he lower end. The tube, 2, indicated by dotted lines, projects beyond the under side of the piston. 15 is a shoulder, and 17 a helical spring, for preventing the lamp tube from sliding off when the lamp is drawn down. Fig. 3 is a section of fig. 1. The piston is shown



midway in the cylinder, and the exhausted or vacuum portion of the cylinder, 6, represents oil, put on the top of the piston, for lubricating the tube, and keeping the leather cups, 8 and 9, which form the packing, air tight. 16 are two small holes, drilled through the body of the piston, which holes are covered by a valve formed of a leather washer, 10, on which the brass washer, 11, is pressed by the spiral spring, 12. The object of holes and valve is to produce and maintain the vacuum by which the pressure of the atmosphere is brought into operation; for when the lustre tube is raised, the air which is included between the bottom of the piston, 5, and the bottom of the said tube, is compressed, and elasticity causes it to raise the leather, 10, and the brass, 11, and escape through the oil, 6. When the tube has been raised to its fullest extent, until the bottom of the said tube is brought into contact with the bottom of the piston, 5, the whole, or nearly the whole of the air is removed from under the said piston, and the spring, 12, forces down the leather valve, 10. On drawing down the lustre tube the oil, piston, and valve, prevent the re-entrance of air under the said piston, and the vacuum existing there causes the lustre tube, and lustre attached thereto, to be supported by the pressure of the air external to the said tube. If from any cause air or oil should have descended below the piston, it may be made to escape through the holes by the raising of the lustre tube. 7 are two small holes made through the piston, 5, for feeding the inner cups, 8 and 14, with oil. The cup or washer, 14, is for the purpose of preventing the gas from passing the sides of the tubes, 2, and coming out at the holes, 7, when the level of the oil is below the said holes. 4 is a cup for receiving a part of the oil when the lustre is drawn down. Fig. 4 is a sectional view of the roof tube, 1, with the piston exhibiting the position of the inner tube, 2. 19 is a screw in the body of the piston, by which the leather cups, 8 and 9, are kept in their respective places; and 18 is another screw for keeping the leather cup or washer, 14, in its place.

SEWAGE MANURE.

WILLIAM HIGGS, of Westminster, chemist, for "*the means of collecting the contents of sewers and drains in cities, towns, and villages, and for treating chemically the same; and for applying such contents, when so treated, to agricultural and other useful purposes.*—Granted April 28; Enrolled October 28, 1846. (*With Engravings, Plate VI.*)

The invention consists, firstly, in the construction of tanks or reservoirs in which the contents of sewers and drains in cities, towns, and villages are to be collected, and the solid animal and vegetable matters therein contained solidified and dried as hereinafter described. Secondly, in the construction of buildings over such tanks or reservoirs in which the vapours and gases, evolved from the collected mass of sewage below, may be collected, retained, condensed, and combined with chemical agents, a hereinafter described, and also in the arrangement of spars or bars on which the salts, formed by the combination of such gases with other substances, may rest or crystallise. Thirdly, in the construction and arrangement of machinery and apparatus to be used in distributing and depositing chemical agents over the mass of sewage collecting and collected in the

NOTT'S ELECTRIC TELEGRAPHS.

FIG. 4.

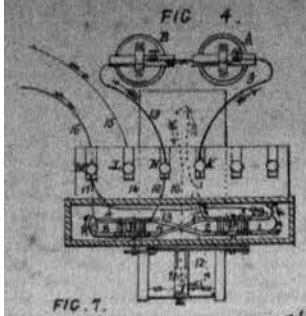


FIG. 6.

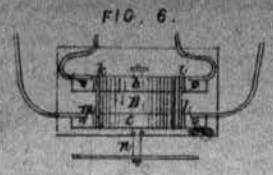


FIG. 5.

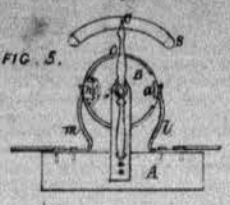


FIG. 7.

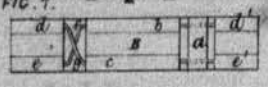


FIG. 10.

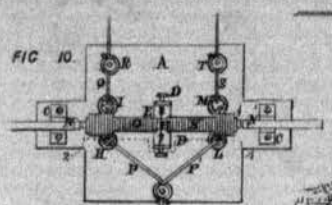


FIG. 12.

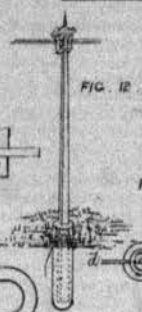


FIG. 11.

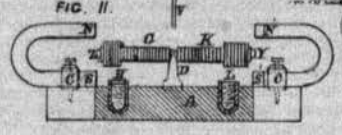


FIG. 8.

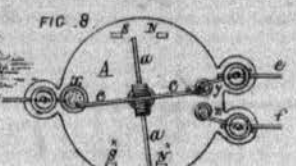


FIG. 9.

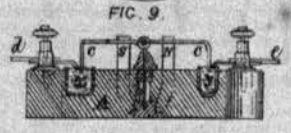


FIG. 2.

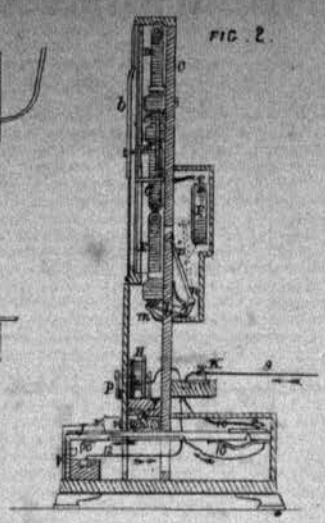


FIG. 3.

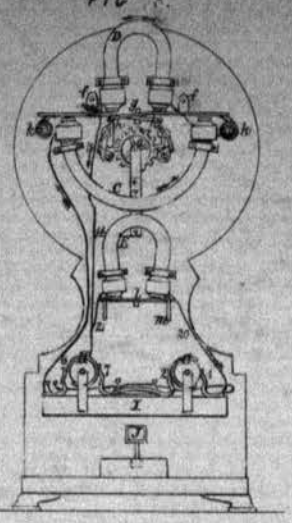
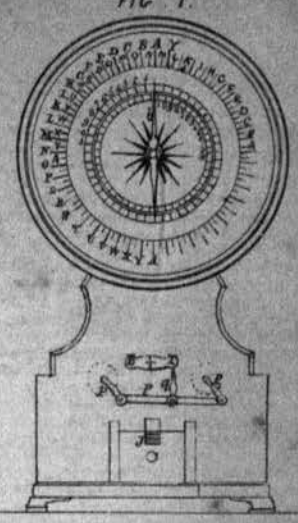
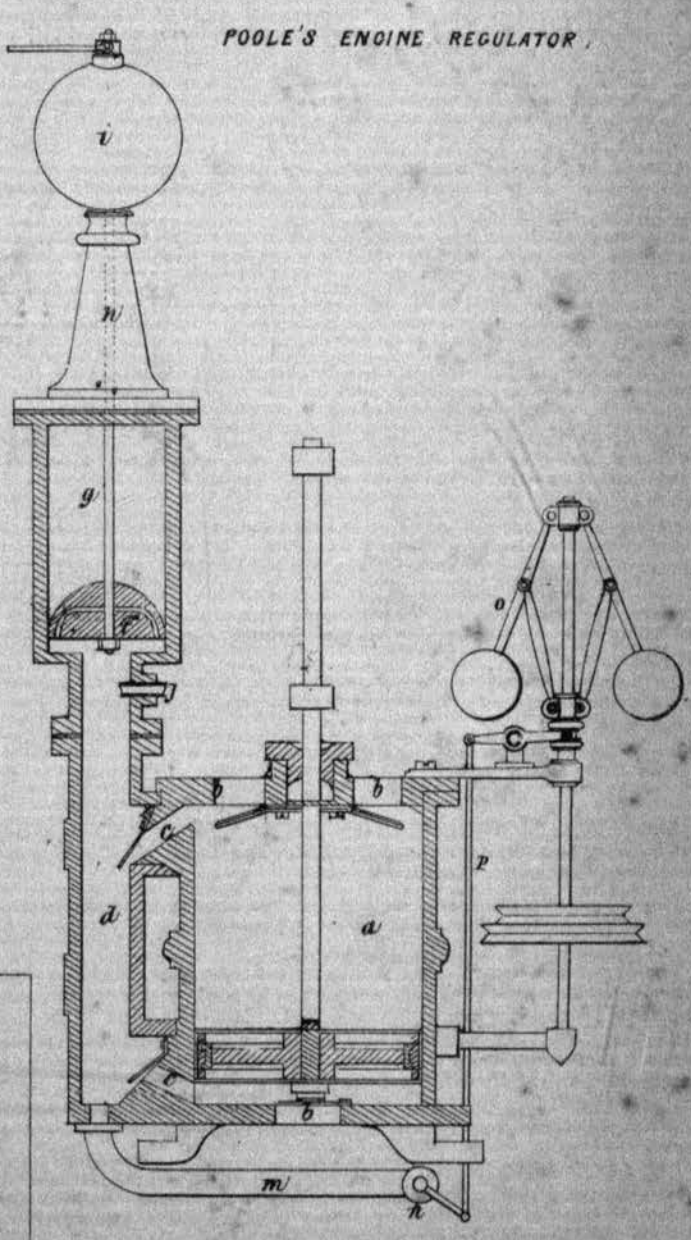


FIG. 1.



POOLE'S ENGINE REGULATOR.



CROLL'S GAS METER.

FIG. 2.

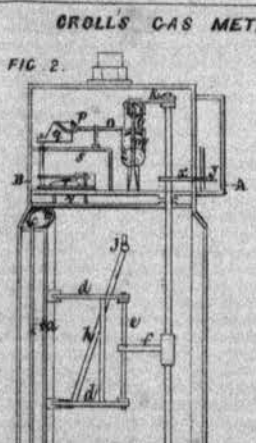


FIG. 1.

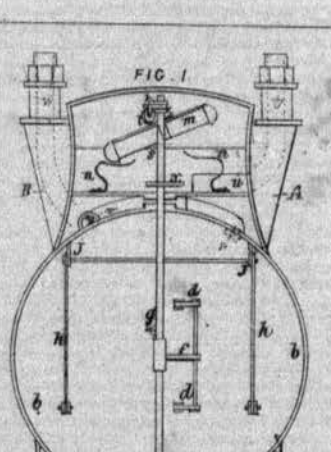


FIG. 3.

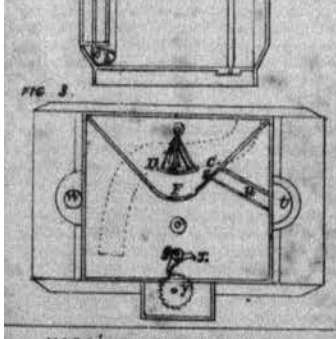
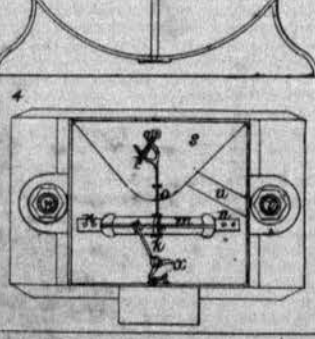


FIG. 4.



HIGG'S SEWERAGE.

FIG. 1.

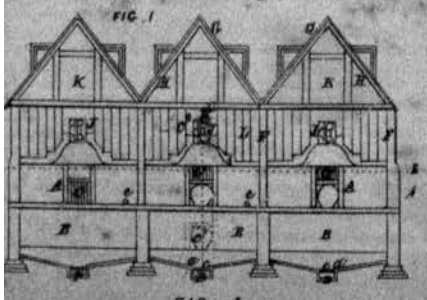


FIG. 2.

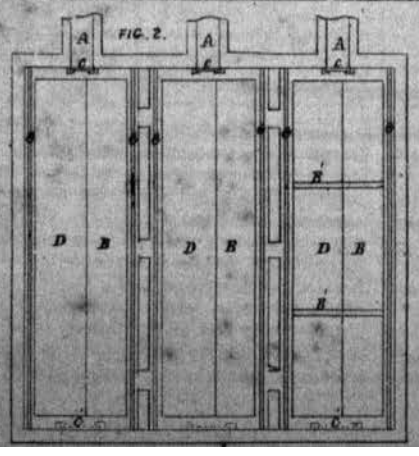
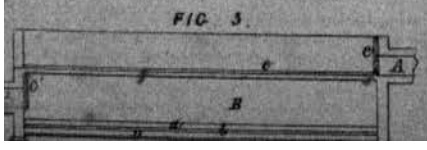


FIG. 3.



tanks or reservoirs above mentioned. Fourthly, in the use and application of chemical agents for the purpose of precipitating the solid animal and vegetable matter contained in sewage water, and also for the purpose of absorbing and combining with the gases evolved in such sewage water, and the animal and vegetable matters contained therein or precipitated therefrom.

The first part of the invention relates to the construction of tanks or reservoirs. Fig. 1 is a transverse vertical section, and Fig. 2 a plan, of three tanks or reservoirs, in which the mass of sewage is to be collected; also a section of buildings to be erected over the tanks or reservoirs in which the vapours and gases arising from the tanks are to be collected and condensed, or combined with other substances. A, the extremities of the sewers, through which the sewas matter is to pass, communicating with the tanks B, in such a manner that the sewage water will run freely into them. The sewers A have sluices C, opened or closed at pleasure, so as to allow or prevent the flow of the sewage water and matter into the tanks as may be desired.

The tanks or reservoirs, B, may be constructed of brick, stone, or other fit materials, and of any number, form, and depth, as may be found most suitable and convenient, according to their local position and the quantity of sewage matter to be treated or operated upon. It is preferred that each tank should be made in the form of a parallelogram, the sides to which shall be three times the length of the ends, and varying in depth from twelve to fifteen feet. The bottoms of these tanks or reservoirs must be so constructed as to drain down to some one or more places where a filter or filters is or are to be placed for draining and drying the solid matter in the tanks, and with proper drains under such filters for carrying off the water passing through them. It is preferred to construct the bottoms of the tanks with double inclined planes, and with drains running down the centres of the tanks, and into which the water in the tanks will drain. Over each of these drains is placed horsehair cloth, or some other porous and filtering material, to be supported upon gratings. The drains under the filters must be made to communicate with a cistern or other receptacle for receiving the filtered water, and so that the water may run freely from them into such cistern or receptacle.

The sewage water from time to time poured into the tanks B, after being deprived of the solid animal and vegetable matter contained therein, is to be let off through the floodgates, C^1, into the water-ways, C^2, so as to leave the precipitated animal and vegetable matter, remaining in the tanks, to be afterwards treated as hereinafter described. The floodgates, C^1, must be placed about three feet from the bottoms of the tanks, so as to leave a convenient space below the level of the floodgates.

When a sufficient quantity of animal and vegetable matter has been collected in a tank, the floodgate is closed, so as to prevent any further flow of sewage into the tank until after it has been emptied of its solid contents. The filtered water contained in the cistern, or other receptacle, must then be pumped up from time to time, or got rid of in some other way, so that the drains under or communicating with the filters may be kept free from water, and the filters so left free to act efficiently.

In order to facilitate the process of depriving the solid matter in a tank of its moisture, a partial vacuum under the filters is formed, so that the pressure of the air upon the contents of a tank may have the effect of drawing the water contained in it down through the filters into the drains below; and for the purpose of producing and keeping up such a partial vacuum, the patentee either uses an air-pump for exhausting the air in the drains under the filters, from time to time, in the same manner as air-pumps are generally applied to such purposes; or he produces and keeps up such a partial vacuum by means of the pump by which, from time to time, the filtered water is to be pumped out of the receptacle.

The tanks B may be subdivided into two or more compartments by divisions, B^1. The line E, E, fig. 1, represents the ground line, or level of the ground, showing how much of the building is to be raised above ground.

The second part of the invention relates to the buildings above the tanks already described, F. Fig. 1 shows the walls of a buildings erected over a set of tanks. G, the roofs furnished with a number of openings H, through which the air may escape. I, are ceilings, furnished with one or more of Day's Patent Archimedian Ventilators J, or other similar machinery, for effecting an upward current and drawing off the vapours and gases evolved from the tanks, and carrying them up into the chambers K, to be condensed or combined with some chemical agents or matters, as hereinafter described.

In the chambers, K^1, are fixed a number of uprights of wood, C^3, and to these a number of spars are secured in a longitudinal position, on which the salts or other substances formed from the vapours or gases may rest and attach themselves, as hereinafter described.

The third part of the invention relates to the construction and arrangement of machinery and apparatus to be used in distributing and depositing chemical agents over the mass of sewage collected in tanks or reservoirs, which arrangement consists of trams or rails, fixed along the edges of each side of the tanks or reservoirs B, on which suitable carriages may travel.

The operator will, by these means, be enabled to distribute the chemical agents or substances equally over the whole or any part of the surface of the contents of the tanks or reservoirs, as may be required. And for the purpose of more equally distributing the contents of the wagon over the surface of the matter in a tank, the bottom of the wagon may be constructed like the hopper of a flour mill, and have motion given to it in the same manner, or any other similar means may, if thought fit, be adopted for making the bottom of the hopper self acting for the purpose of distributing or throwing down its contents into the tank below.

The fourth part of the invention relates to precipitating all the solid animal and vegetable matter contained in the sewage water from time to time run into the tanks, and to cause the vapours and gases arising therefrom to be condensed, absorbed, or combined, with some other substances in the chambers above. For this purpose, hydrate of lime, commonly termed slaked lime, is preferred, being the cheapest and most efficient chemical agent for effecting it.

For the condensation of the vapours and gases arising from the mass of sewage, it is proposed to use chlorine gas to unite with and condense all such vapours or gases as are composed of ammonia, or sulphurretted hydrogen, which are evolved whilst sewage matter is collecting or under the chemical treatment in the tanks or reservoirs. Hydrochloric acid gas, and some other chemical agents, may perhaps be capable of effecting the condensation or absorption of the various vapours and gases arising from sewage matter, but chlorine gas is preferred, because of its efficacy and the facility and economy with which it may be obtained.

The solid animal and vegetable matter remaining in a tank after the greater part of its water has been drained out of it by means of filters, as before described, ought to be dried so as to prevent the chemical decomposition of it, and render it fit for being transported to distant places, for application to agricultural or other useful purposes.

This solid matter ought first to be formed into pieces of suitable shapes and dimensions, and then dried by any means which may be most convenient according to circumstances.

SHIPS' LOGS AND SOUNDING MACHINES.

THOMAS WALKER, of Birmingham, stove maker, for "*Improvements in ships' logs and soundings.*"—Granted June 22; Enrolled December 22, 1846.

These improvements relate to apparatus for registering the speed of vessels and sounding depths at sea. The first to registering the speed of vessels by external or internal rotators. Fig. 1, shows the rotatory placed on

Fig. 3.

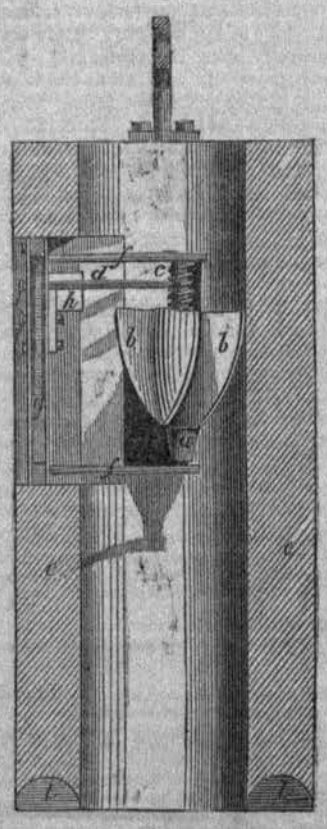


Fig. 4.

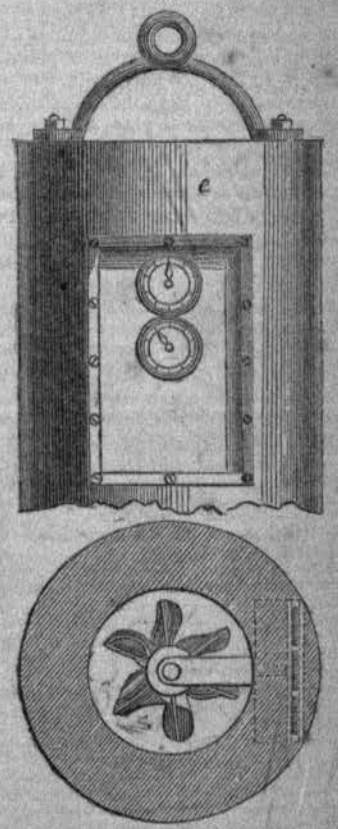


Fig. 5.

one side of the vessel, with its index above the side of the ship. *d* is a suitable metal tube, inclosed in the connecting medium, such as rope or chain; *a*, is the rotator; *b*, the rope, with a universal joint attached. Fig. 2, is a view of another description of rotator for registering the speed of currents, which is contained in a circular box or tube, *a*, having flanges for the purposes of removal; *e*, *f*, are metal tubes, formed in the manner shown in the cut; *d*, is a vacuum pipe, for the purpose of extracting the air and filling the tubes with water, to admit of a passing current through the blades *b*, *h*; *g*, is the water line. The whole apparatus being above it, more readily admits of repairs. Figs. 3, 4 and 5, represent the application of the rotator within the weight or cylindrical metal *e*. *a* is the rotator; *b*,

the blades; *c*, the screw into which a small pinion takes; *d*, the pinion spindle; *e*, *e*, the weight or cylindrical case; *f*, *f*, horizontal bearings; *g*, tooth and pinion wheels; *h*, a longitudinal stop; *i*, *i*, indicators; *l*, *l*, a semicircular channel, fitted with an adhesive compound for the purpose o

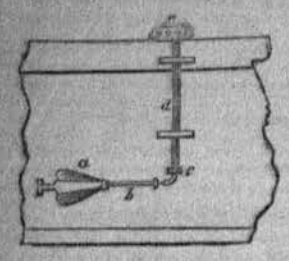


Fig. 1.

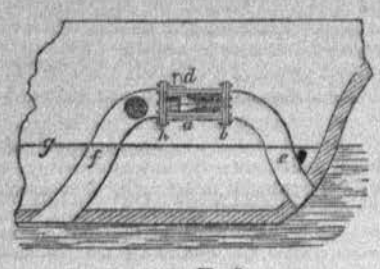


Fig. 2.

ascertaining whether the log reaches the bottom or not, by collecting particles of dirt or rubble therefrom. The action is as follows:—The log, on descending rapidly through the water, causes the blade *b*, to rotate, which is transmitted to the tooth and pinion-wheels, *g*, and from thence to the hands or indicators *i*, *i*, which revolve until the log has reached the bottom, when it is necessary, in order to keep the hands or indicators in the position last indicated by the motion of the rotator, to employ the stop, *h*, which is put in action by the pressure of water when the log is being withdrawn, thereby preventing a retrogressive movement of the hands.

GODDARD'S IMPROVED ANEMOMETER.

It consists of a double vane, shaped like a truncated cone, the small ends being fixed to a brass tube about 1 inch in bore; this tube, penetrating the roof, rests on a hollow socket fixed into a table, which supports the instrument; immediately above the table the tube passes through a solid cylinder, whose top is cut oblique to the axis, thus forming a solid, termed a hoof, the tube forming its axis; so that as the wind shifts its quarters, vane, brass tube, and hoof, all revolve together in the plane of the horizon: beside this rotating hoof, a brass piece is placed vertically upon the table, and has a slit in it, so that a slider, containing a pencil, may rise and fall as the thick or narrow part of the hoof comes under the sliding pencil, the former being the case with a north wind, and the latter with a south wind. Therefore it will be understood that the pencil is lifted to the top of the scale at north, and depressed to the lower end by a south wind; the east and west occupying the mean or middle, it will be readily seen that the east and west are in the same place on the scale; but in order to distinguish them from one another, a pencil (below the former pencil in its lowest excursions) is made to mark in the eastern semi-circle, and remain inactive on the western. This is the *direction* of the wind-pencil.

To the minute-hand of a clock is attached a light arm, which, being connected with another pencil by means of a beam (similar to that of a steam-engine) placed in the same slider, only above the highest limit of the direction-pencil and its auxiliary, alternately raises and depresses it, according as the minute-hand points to 30′ or 60′. This is the time-pencil. Inside the brass tube an iron rod passes, connected at the upper end with a fan wheel, which the wind turns in proportion to its velocity; and to its lower end with an endless screw, which, communicating a motion to a few simple wheels, gives a slow rotating motion to a cylinder, upon which a sheet of paper is fixed: upon this cylinder, and whose axis is vertical, all the pencils describe their evolutions. The office of the two first pencils is to record the direction, and of the last the time and miles of wind; it being previously ascertained how many revolutions of the fan-wheel correspond to a mile or ten miles of wind.

The advantages of this anemometer are stated to be:—

1. That the scale of time is five times greater within an equal compass of paper than Mr. Osler's.
2. That the register of direction is fully eight times as large, with equal sized sheets, as that of the ordinary construction.
3. The data registered are more comprehensive than those of Whewell's, Osler's, or Foster's, viz.:—
   1. Miles of wind blown during the day.
   2. Miles of wind blown in each direction.
   3. Miles of wind blown between any given periods.
   4. Hour and minute of the highest gust.
   5. Hours in which most wind has blown.
   6. Times of calms, and length of continuance.
   7. Velocity of wind at any hour.
   8. Time occupied by the wind going any certain distance at any period of the day.
   9. Direction of wind at any minute.
   10. Mean direction.
   11. Direction of longest continuance.
   12. Direction of greatest passage of wind.

INTERNAL FITTINGS OF ST. DENIS.

In the *Annales Archéologiques* for October, appears an able criticism, by the Baron de Guilhermy, of the recent restoration of the Abbey of St. Denis, near Paris. The severity of this paper, from which some extracts are given below, is fully justified by the obvious incompetence of the architect, and the desecration of an ancient and beautiful edifice by modern make-shift expedients. We can testify from personal observation that the architecture of the Abbey now looks very *pretty*, but prettiness and the imitative decoration now exhibited in St. Denis are worthy only of the gaudy shops in the Palais Royal.

"The capital vice of the actual decoration of St. Denis is to our eyes the absence of all serious character. You would fancy you saw the work of a sceptical and mocking age, which, forced to raise up again the ruins of the old church, wished to indemnify itself for this constraint by treating in the most cavalier fashion things of a class altogther grave and respectable. Here they have played at catacombs, and at primitive Christians; there they have pruned away from the legends the miracles which God could not have wrought without wounding our reason; elsewhere they give you, by way of tombs of the martyrs, blocks of stone which only possess the appearance of such, and altars really consecrated shelter under their tables those lying representations; finally, to crown the derision, two or three square metres of bad red serge, hung to a pole of gilt wood, at the end of the apse, sacrilegiously parody that glorious Oriflamme of France, which our fathers, in their religious enthusiasm, imagined was sent down from Heaven, and placed by an angel in the hands of the first Christian king.

"*Chapels of the Nave.*—Seven chapels border the nave of St. Denis on the north; the first serves for a lodging to the guardians of the church, and the seventh is occupied by the two mausoleums of Louis XII. and Henry II. The five other chapels have been restored to the purposes of worship, and at the present hour the last hand is being actually put to their decoration. Two alone amongst them, those of St. Martin, and the Trinity, preserve their ancient titles; the three others, which bore the names of St. Lawrence, St. Louis, and St. Denis, have lost their old patrons. But an illustrious martyr, like St. Laurence, a king like St. Louis, an apostle like St. Denis, merited some regard; accordingly they have given them a compensation in the chapels of the apse, where they have in their turn supplanted saints of a less value. The confusion resulting from all these displacements, will in no little degree obscure the history of the Abbey, for him who would wish to study it in the different works left by the Benedictines. It was not without a motive that the monks of St. Denis had settled the titles of their different chapels; the choice of each patron was connected with some remarkable circumstance in the history of the monastery.

"At St. Denis the decoration of the lateral chapels of the nave has been treated as if it were a case of furnishing the halls of a museum. The people who had suppressed the Museum des Petits-Augustins, and who no longer knew what to do with the immense quantity of fragments of which this collection was composed, entertained the unhappy thought of enriching St. Denis with the spoils of a hundred churches. On their side the architects gave themselves incredible pains to make use of all these *debris*. So that the eye is every where shocked with a disorderly accumulation of sculptures which have neither connection of subject nor community of origin, nor analogy of style."

"Four bassi-relievi of the sixteenth century are fixed in the wall."..... "In order to give this chapel an altar worthy to figure in the midst of a like disorder, they have gone and chosen in the magazine of arches, several pointed arches of the thirteenth century in coloured stone, formerly comprised in the decoration of the charming apse of the Sainte Chapelle at Paris, and on these supports of a new sort is placed a great slab which forms the table of the altar. At one stroke the Sainte Chapelle has been deprived of an important portion of its ancient ornamentation, and St. Denis has been enriched with a pitiable monument. These arches so disposed form an open space, a sort of cage, whose bars emprison a statue reclining on a sheet; look at it well, and you will recognise the lover of Diana of Poitiers, (Henry II.) who here fulfils the functions of a Christ in the sepulchre."..... "Above this altar of sufficiently profane composition rises a curious reredos of wood worked with more patience than art."..... "The style of this sculpture proves a Flemish origin. Finally our chapel has been entirely painted; but, in place of clothing it with those brilliant colours of azure and gold for which the middle ages had such an affection, they have given it a costume of the saddest and palest tint. Certain columns reproduce, on a gigantic scale, those innocent sticks of apple-sugar or chocolate which our confectioners display less to cheer our eyes than to excite our *gourmanderie*. If, as they have dared to say, the money to do better was wanting, would it not have been fit to have waited? The church of St. Denis will survive us. A pretended drapery of a greenish colour, powdered with meagre ornaments of gold, (if it can be so called,) hangs heavily all round the chapel, to the lower part of the walls. Higher up, house-painters, turned into historical painters, have executed two abominable frescoes representing Moses on Sinai, and the Last Judgment. In the scene of the Judgment the tribunal only is given; the whole human race is missing. Let us not forget to mention, by way of memorandum, three or four bad modern pictures straying about this toy-shop, and to state that at this very moment workmen are finishing a great beam

starting from the mouths of dragons, which will soon be, if the new architect does not rectify it, planted across the arch of the opening of the chapel; this piece of wood will serve as support to some twenty bad little statues, which will be disposed like a calvary, such as still exists in certain rural churches, particularly in Britanny. I simply announce these facts: they speak sufficiently for themselves, without their having need of a commentary."

In the choir to the south of the nave some ancient wood-work was pressed into service, of which—

"Two bassi-relievi were missing; to replace them, they have modelled twice over in papier-maché, a Preaching of St. John Baptist, which is thus found thrice repeated. All the little statues which were destroyed, have been also restored in papier-maché. This wood-work, of which the execution is admirable, is now found so glued over with oil-paint (*quære* varnish?) that one can no longer appreciate the delicateness of the tool: the figures and the misereres of the stalls have had the same fate. Some panels of the wood-work offered no subject; they have caused marquetry work to be imitated there by the pencil—every where and always the intention to deceive the eye." "They have had the barbarity to use up, to cut, to pare doors, which came from Gaillon, which passed for a *chef-d'œuvre*. They have employed the pieces to make a frame for the painting over the principal altar, benches for the choir-boys, and desks for the cantors. "In a sculpture of the Nativity in this choir, they forgot, while restoring it, to place Our Lord in the cradle."....."In this same choir are now found the monuments of some abbats of St. Denis; they are the only ones which the revolution has not destroyed. But before they found here the right of asylum, they have been compelled to suffer rude outrage."—"They also devised the fabrication of a Suger, by means of a grotesque face of pure fancy, taken from a boss of the ancient cloister, a bloated and trivial face, recently illuminated with a drunkard's red."....."From four or five Apostles of the Sainte Chapelle which had been carried to St. Denis, they have drawn out the twelve by moulding them one upon another. These twelve figures, executed in plaister, are placed against the pillars of the winter choir."....."A glazed enclosure guarantees the canons from every current of air, it is a real frame of glass, set in plaister foliage, and papier-maché mouldings. The poor royal church is cruelly expiating its passed magnificence."

"We have not to talk either of the high altar, nor of the stalls of the great choir, nor of the mosaic pavement of the sanctuary; they have none of them any archæological pretensions; let us leave them in peace. The choir is paved in black and white squares, just like the vestibule of a *bourgeois* house, or a dining room. At the extremity of the apse, two marble columns annulated like those of the twelfth century, and crowned with capitals of the thirteenth, carry a wooden platform, on which repose, in shrines of gilt bronze, the relics of the three martyrs, and which serves at the same time as canopy to the seat of the first dignitary of the chapter. They have also cut up by slices some precious wood-work of the chapel of Gaillon to compose with it a niche for the armed chair of the *primicier*, which has remained empty since 1830."

"*Chapels of the Apse.*—If we run over the chapels ranged round the apse, we again find there all the faults which abound in those of the nave."....."Plaister displays all its magnificence in the whole circuit of the sanctuary."....."As the height of luxury they have spread with full hands on the borders of the tables of the altars, nasty pieces of glass picked up in the stalls of the Boulevards." "In the chapels of St. Benedict, St. Geneviève, and St. Eugenius, under the tables of the altars, great tombs of stone, which appear to contain bodies of the saints, are each fairly composed of a huge block, of which the exterior alone has the form of a sepulchre..... In the chapel of St. John Baptist, a cross of the fifteenth century, a curious monument extracted from the ancient cemetery of the Innocents, is now planted on a balustrade. This cross finds itself exalted on a column channeled in chevrons, in the style of the twelfth century; it is sustained by a bar of iron, without the aid of which it would immediately fall upon the pavement. The Virgin and St. John the Evangelist ordinarily accompany, as is known, the representation of Christ upon the Cross;—they thought of placing here the statues of these two personages. It was not very difficult to procure a St. John; but there was a want of a suitable Virgin. What was to be done in this penury? The restoration of St. Denis is fertile in expedients. A very innocent Apostle was condemned to the punishment of decapitation, and on his masculine shoulders they adjusted the head of a woman with tearful eyes. On the façade, they had travestied the Virgin into a man; they wished to give her her revenge. But unhappily in spite of the feminine head and veil, we travellers by the old roads recognise the poor Apostle, by the book which he carries, and the bareness of his feet.

"We trust the reader will pardon us such minute details. We have reserved the strongest for the last. They had in their hands the front of a sarcophagus, which may well date from the eighth century. What a windfall for people who have seen Rome, and know a little of their catacombs. The front of the tomb, in spite of its purely funereal inscription, has become the front of an altar. If we complain of it, they answer us that it is seen at Rome in all the basilics. On the marble has been placed a reredos of a new make, with Monogram, Fish, and Dove; one might really fancy one's-self at the end of the grottoes of St. Sebastian. In order to render the illusion more entire, and the parody less imperfect, they conceived the idea of expressing in a lively manner, the defeat of paganism, and this is the way they set about it. At the sale of a defunct antiquary, of I do not know what illustrious society, they purchased a little marble vase perfectly intact, sculptured with an eagle, and decked with an epitaph. This sufficiently impure vase was destined to become a reliquary. A primitive Christian could not have seen without horror upon an altar, the eagle of the persecutor, and the names of the Dii Manes; two strokes of the chisel therefore dealt justice to these pagan emblems, and on the *debris* of the eagle, they traced a cross, which they took care to make as awkward as possible, in order to make it pass for the work of a primitive Christian, fanatic and maledroit. It is thus that at St. Denis they make a joke of the Christianity of the catacombs."

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

SOCIETY OF ARTS, LONDON.

Jan. 14.—JOSEPH PAYNE, Esq., in the Chair.

The first communication read was "*On a new Condensing Rotary Steam Engine*," by Messrs. CORDES and LOCKE. Models and drawings of the invention were exhibited.

This is an invention belonging to the numerous class of rotary steam engines, but differs from them in two respects. 1st. That whereas they have extensive rubbing surfaces, which require great accuracy and careful packing, and are attended with much friction and loss of power, the newly invented engine has no packing and scarcely any friction, being merely a wheel or vanes revolving within a case, and receives impact from the steam as it passes from the cylinder to the condenser. 2nd. That whereas the common engine, revolving at high velocities, has to encounter great resistance from the air, this wheel revolves in vacuum, by means of a condenser worked by a triple pump, separated from the machinery of the engine. The proof which the patentees offer of the excellency of the engine, consists in the results of certain experiments, made on a large scale, in pumping water, and in direct competition with engines of the common form; in which experiments, it was made to appear that the same general useful effect was obtained from the new as from the old engine, but with a much simpler and cheaper apparatus. The paper concluded with an account of a large experiment, in which the rotary engine was used as an auxiliary to a common engine, with a gain of one-third more power.

Mr. CORDES gave an interesting account of the working of the engine, and the results of the various experiments that had been made; after which a lengthened discussion took place, in which Mr. Newton, Mr. Rotch, and other scientific gentlemen and engineers, bore testimony to the ingenuity of the invention. The cost of constructing an engine on Messrs. Cordes and Locke's principle is stated to be from £15 to £20 per dynometric horse-power, exclusive of boilers, the weight of engine per horse-power not exceeding 4 cwt.

ROYAL SCOTTISH SOCIETY OF ARTS.

Dec. 14, 1846.—DAVID MACLAGAN, M.D., F.R.S.E., President, in the Chair.

The following communications were made:—

1. "*On the means of Preventing Accidents to Railway Trains.*" By J. STEWART HEPBURN, Esq. Two expedients are proposed—for preventing collisions, and for rendering them less fatal when they do happen. To prevent collisions, he proposes a break of a much more effectual kind—not rubbing on the tyre of the wheels, but pressing down upon the rail, and at the same time lifting two of the wheels off the rail altogether. This he proposes to be worked from the last carriage in the train, and gradually to be taken up by the next break in front, and so on to the locomotive. In this way there would be no danger of the carriages in the after part of the train running into those in front when the breaks are applied.—To render collisions less fatal, if they should happen, he proposes to have one of the luggage vans, both in front and in the rear of the train, fitted up as buffer wagons, with a set of very strong springs at both ends of the wagon, to deaden the stroke, still continuing the usual buffers in all the other carriages.

2. Description and drawing of an "*improved Railway Indicator and Alarum.*" By Mr. ANDREW CARRICK. He proposes that a lever be attached to the locomotive (with a rule joint to prevent its action on reversing the engine), which shall come in contact with a short inclined plane, at a certain distance from each station, when the engine should be slowed. The lever is pushed upwards by the incline, and strikes a bell, which gives notice to the engineer, especially in foggy weather, immediately to take the steam off, as he is approaching a station.

3. Description of an "*Ink to be used in Writing to the Blind, with some remarks on whether the Roman Alphabet should be used, or one of easier formation by the Pen.*" By ROBERT FOULIS, Esq. The ink is of a peculiar kind, composed of common ink, acetate of lead, and gum arabic, by writing with which on common paper, the letters, which must be of a tolerably large size, are easily felt and read by the blind. This was proved by his making a blind boy read several sentences which he had not previously done. Mr. Foulis also goes into the question, whether it would not be better, in writing to the blind, to have an arbitrary character of easier formation with the pen than the Roman alphabet.

4. Dr. Wilson exhibited in action, and described an "*Electro-Magnetic Coil Machine*," constructed by Messrs. Kemp and Co., Infirmary street, and showed that Mr. Brown's coil machine, lately exhibited, is made on the same principle as Mr. Kemp's, which had the priority.

Jan. 11.—George Tait, Esq., V.P., in the Chair.

The following communications were made :—

1. Description, with a drawing, of an "*Hourly Self-Registering Barometer.*" By Mr. P. M'Farlane. He proposes to have twelve barometer tubes placed side by side in a case dipping into separate cups of mercury, the lower end of the tubes being bent at a right angle, and ground even at their mouths. A valve is fitted to act on each of the mouths, and to the other end of the valve is attached a lever, on which at every hour, a wire moved by clock work presses and shuts each valve in succession : thus retaining the mercury in each tube at the exact height at which it stood at that particular hour of the day or night, and as they are all read off at one time, there will be no occasion for correction for temperature.

2. Proposed improvement in "*Locomotives and Railway Carriages, particularly in their Wheels and Breaks.*" By Mr. J. Wight. He proposes a new form of wheel for the running wheels of locomotive engines and railway carriages. In place of running in a vertical direction, which he finds by experiment to be very apt to cause the wheels to leap off the rail on arriving at some impediment, perhaps a very slight one, especially when on a curve, he proposes to have the wheels (except the driving wheels) running at an angle of 45 degrees, the upper part of the tyre to be next the carriage, and the lower part of it upon the rail, with two sets of spokes, one set as at present, and the other vertical, so as to bear the weight of the carriage. He conceives their axles, which are to be separate, and not in one piece as at present, will be much stronger, though lighter, for the section, taken at the angle of 45 degrees, is stronger than a section perpendicular to the horizontal axle. But the chief improvement he conceives, consists in their safety, having no tendency to run off the rail, although upon a curve of small radius. He also proposes that the break, instead of checking the wheel by rubbing on the tyre, should be made to rub upon the rail itself. The break to be about 2 feet long, so as to present a large rubbing surface to the rail, and to be moved by the ordinary lever or screw power.

3. On a new and improved "*Method of Saving Life on Skating Lochs and Curling Ponds.*" By Mr. James Baillie. He proposes to have a flat-bottomed boat, with mallets, ropes, short ladder, and other implements, kept at the side of the loch, and a long rope also to be managed by two men at the opposite sides, who, when any one has fallen into the water, can speedily bring this rope over the spot, which the person immersed may lay hold of until the boat arrives.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Jan. 11.—Mr. Tite, V.P., in the Chair.

A paper was read on the Ancient City of Syracuse, by Samuel Angell, V.P., which is given in another part of the Journal.

Mr. Scoles, honorary secretary, exhibited a drawing of an ancient bath in Syracuse (he considered it Roman), the vault of which was formed by earthern cylindrical tubes, 2½ inches in diameter, like a wine-bottle with the bottom out, the smaller end of which entered the larger end of the tube next it, and so, without involving the principle of the arch, formed a vault, in this case seven feet in span. The tubes were filled with cement, and covered on the top with a layer of tiles.

Mr. Donaldson communicated a paper, "*On a mode of Measuring and Valuing Carpenters' and Joiners' Work, with the view of obtaining greater correctness than by the mode now pursued.*" By Mr. Browning, architect.

Mr. Tite said, architects had been told recently, in a work which had attracted some notice, that this was a matter with which they should have nothing to do. But the fact was, they couldn't help it, and moreover would not do their duty towards their employers if they neglected attention to it. He had himself no liking for measuring and valuing, but nevertheless he was obliged to do it. As to any change in the mode of measuring, he thought it would have to come from the operatives rather than from the profession. That it was much needed there could be no doubt. The mode of measuring stone was especially empirical. Measuring first the cube stone, then "face," "bed," and "joint," as plain work ; then the sunk work ; then the moulded work ; led to a false result. Sir Robert Smirke, at the Post Office, had struck a blow at the system when he refused to allow the bed and joint to be measured, and gave an increased price for the cube stone. The engineers had cut the knot which the others attempted to untie, by measuring the cube stone and nothing else, including all labour in the price. This, however, was manifestly an unsatisfactory mode. Returning to the general question, architects were bound to see that their employers were fairly dealt with. It was easy to certify an amount, but no man should do so unless satisfied as to its correctness. The art could not be separated from the business. Measuring might be delegated to others, but even then the architect was justly held responsible. It was so also in Greece, where, if an architect's estimates were exceeded in the execution of the works, his own fortune was liable for the difference.

[Will Mr. Tite tell us how to get at the labour of sawing the stone and sunk work and other labour connected with beds and joints, or the labour on the face, without first measuring them. It is very true that builders, to suit the convenience of some architects, give a price for stone per foot cube, including beds and joints ; but before they do so, they first calculate from an average, in the best manner they can, the value of the sawing and setting, and then add it to the price of the stone. The only advantage of such a practice is that it saves a little trouble in measuring the work, allows a clerk of the works to measure the stone work, and dispenses with the employment of an experienced surveyor. In the same manner, it might be advocated that buildings should be taken at so much per foot cube, and doubtless this method would save much trouble ;—but what dependance could there then be in the correctness of the value of the work and labour done ?—Ed. C. E. & A. Journal.]

The Papworth Testimonial.—Several architectural friends of Mr. Papworth, on his retiring from the profession as an architect, at the age of 70 years, met at Mr. Donaldson's house, in Russell-square, on Monday, the 25th ult., to present him with a beautiful Silver Inkstand, "as a tribute of their respect and esteem for his talents as a distinguished architect, and for his worth as a man." The testimonial was presented, with an eloquent oration, by Mr. Cockerell,—the lateness of the month prevents us giving even a brief outline of it, or Mr. Papworth's reply.

INSTITUTION OF CIVIL ENGINEERS.

Jan. 19.—*Annual Meeting.*—Sir John Rennie, President, in the Chair.

The following gentlemen were elected officers for the ensuing year : *President*, Sir John Rennie ; *Vice-presidents*, W. Cubitt, J. Field, J. M. Rendell, and J. Simpson ; *Council*, J. F. Bateman, I. K. Brunel, J. Locke, Sir J. Macneil, J. Miller, W. C. Mylne, T. Sopwith, R. Stephenson, G. P. Bidder, J. Cubitt, Captain Coddington, and C. Holtzapffel.

Telford medals were presented to Messrs. Barlow, Snell, Harding, Williams, Parkes, West, and Ritterbandt ; and premiums of books to Messrs. Turnbull, Heppel, and Robertson.

Council Premiums, consisting of collections of books of considerable value, were presented to Messrs. Barlow, Snell, and Harding, in addition to the Telford medals. Succinct memoirs were given of the deceased members, Messrs. Crane, Deville, Handley, and Winsland.

The Report, which stated that the Institution was in a most prosperous condition, entered fully into a description of the alterations of the building during the recess. The principal works appeared to be the remodelling the basement story, putting a portico at the entrance, and balconies to the first and second floors, and enlarging the theatre. Thanks were unanimously given to Mr. T. H. Wyatt, the architect, Mr. Grissell, the builder, and Mr. Manby, the secretary, who superintended the execution of the works.

The President's Address.—Sir J. Rennie, after alluding to the stimulus the profession had received from the number of public works recently undertaken, and the high position which the Institution had obtained from the successful labours of its various members, impressed on them the necessity of still further exertions, in order to support the scientific character they had earned. He then reviewed the progress that had been made in railway travelling and steam navigation, and made some valuable remarks on the formation of bar harbours and the drainage of extensive districts of marsh lands. The president then remarked upon the appointment of civil engineers by government to investigate into the merits of various projects which had been submitted to the Health of Towns Commissioners, and observed, that if the same system had been pursued with regard to railways, the public would have derived infinitely greater advantages than they were likely to do from their present system. Sir J. Rennie concluded his able address by thanking the officers and members of the Institution for the kindness, attention, and support which they had on all occasions exhibited towards him.

Thanks were voted to the president, vice-presidents, and other members of the council, and to the secretary, and the meeting adjourned.

NOTES ON FOREIGN WORKS.

Machine Manufactories in Germany.—The construction of the manufactory established at Esslingen (Würtemberg) proceeds rapidly. On the 1st of May last, the building, 1000 feet by 60 feet, was begun, and one half is now completed, and workmen are already employed in the carriage department. For removing the single engines, some new water-works are being erected, the establishment having a 100-horse water power at its command. The annual produce will amount to 600,000 florins (£150,000, English), and employ 500 workmen. It will shortly be completed, and thus Würtemberg will not only produce her own locomotives, wagons, and other railway requisites, but it is said that even the Roman lines will be supplied from Esslingen. The direction is confided to M. Kessler, and government has assisted it with every facility and aid desirable. The same gentleman was also the founder of the Karlsruhe manufactory, commenced in 1837, which has since 1842 produced an immense quantity of railway implements. It now employs 860 workmen, and since its erection

has constructed 70 locomotives, and 90 are now in hand, for the lines of South Germany, Switzerland, Hanover, Prussia, &c. If the making of turn-tables, bridges, and other structural parts of railways, be taken into account, the activity of these two establishments may be easily calculated. Occupying, jointly, 1300 workmen, and producing 2,000,000 fl. (£350,000) of work a-year, they may vie with any establishment in Belgium or England. Ten years ago, any such plan would have been considered in Germany quite impracticable and chimerical.

M. Rugendes, the painter, who has travelled twelve years in different parts of South America, the Brazils, &c., has brought back a collection of about 3000 sketches, some of large size. The views of American cities, and their chief buildings, with architectural details thereof, will be the more interesting, as plans of the ancient structures erected by the Jesuits, and even the new public buildings of these infant commonwealths, are not sufficiently known.

Interruption to the great Water-Works at Hamburg.—These important works have come to a stand-still, by the burghessen council having refused a supplementary grant of some 500,000 marks. This, after millions have been already expended, seems a strange manner of doing business. It is said, however, that the citizens of Hamburg never contemplated the erection of such stupendous show-buildings; besides, yielding to private interests, and other paltry practises, are also objected to.

Great Scientific Prizes in France.—Our French neighbours regret, very justly, the falling into disuse of those *prix décennaux*, instituted by Napoleon, towards which, not merely monetary graspingness, but legitimate emulation, were once aspiring. Still, the prizes proposed every year for the advancement of science are *greater* in France than in any other country. We report on the present occasion one of the *Prizes of Argenteuil*—viz., "Is the intervention of water, in the state of combination, necessary for effecting chemical reaction between acids and their bases?" This important question has been treated by M. Frémy in his interesting memoir "On the Hydrates." It has been completely refuted, by the experiments of this philosopher, that all anhydrous acids (*i. e.* those deprived of water) cannot combine with bases; which signifies that they have lost their quality of acids. He then proves that the carbonic, sulphuric, sulphurous, phosphoric, and other acids, combine very well, in their anhydrous state with bases. And it is only those compounds which are both acids and bases in their turn, which require the existence of water for displaying their chemical affinities or attraction.

The New Great Prussian Line.—The Berlin government have definitely decided on a direct line to Kœnigsberg, which will be begun next spring. It is said that this resolution has been hastened by that of the Russian authorities, who intend to construct a line from the Interior to the Prussian frontiers.

Frost-Phenomena at Rome.—The present severe winter has imparted to the capital of the artistic world a strange appearance: the palaces of the Emperors, the Coloseum, triumphal arches, and temples, are covered with a thick coat of ice, and the wide plain of Latium, from the mountains up to the Mediterranean, is covered with a crust of snow, which even the mid-day rays of the sun are unable to melt.

Impracticability of Continental Railways in the Winter Season.—All the lines in the north of Germany have been, more or less, interrupted by the late severe frosts; as, for instance, the Berlin and Silesian, as well as the Berlin and Hamburg, which had been only opened a few days previous to being thus obstructed. On the frontiers of the Mark and Silesia, where the line has been carried through the forests of the Lausnitz, a company of sixteen or twenty travellers had to remain a whole night on the rails, on which the engines had been frozen in; and in the village of Kohlfurth there were, at one time, six trains stuck fast, so that no others could proceed, although three lines cross each other at this point. The mails and passengers were obliged to be conveyed on sledges.

Destruction of a high-road near the Rhine by an Earthquake.—A most extraordinary phenomenon, caused by the upheaving of the earth (similar to those which sometimes occur in South America, &c.), has lately taken place at Unkel, on the banks of the Rhine. In this neighbourhood, there exists a quarry of basalt, from which the stone is taken for the high-road. Between this basalt-stratum and the Rhine a large plain extends, through which passes the high road. This plain has now been converted into a mount, and the road thrown up 100 feet into the air. The locality resembles a place blown up by the bursting of a mine. Some minutes before the eruption took place, a terrible roaring was heard, like the approach of a hurricane, which caused the mail-drivers, who were passing at the time, to hasten away. This, however, was not heeded by a carter, whose vehicle, with a load of 5,000 kilogrammes, was rolled like a pebble, lifted up in the air, and then buried 100 feet beneath the ruins of the falling rocks. To the north of the basalt stratum extends a vineyard, on a high elevation of ground: this mountain was ripped asunder, at the same time that the plain was upheaved. The appearance of the spot is altogether extraordinary and curious.

Naples.—Two new churches, of good style, have been lately erected here, likewise two large public fountains, with antique figures and bas-relievos. Broad footpaths have been laid in the most frequented streets, as far as Posilippo, and the square before the church of St. Francisco macadamised, which hitherto has been very uncomfortable to the public. High-walled, broad quays line the shore, up to the Villa of St. Lucia; —still, landscape admirers say, that the former rocks and gravel, binding the sea were more picturesque. An artesian well is being dug in the gardens of the Palazzo Reale, and huge iron gates are being erected, on the grand pedestals of which the two bronze horses, presented hither from St. Petersburg, are to be placed. A large heap of splendid gold coins of the oldest period of Roman history, have been discovered at Pompeii, which has filled our antiquarians with extasy.

An Italian Model Railway.—The line between Lucca and Pisa has been lately opened, and the communication between the two cities takes place four times a-day, and on holidays—as those set forth for the recreation of the humbler classes—five times a-day. The line was constructed under the direction of M. Dohlmeyer, a German engineer, and is built in a very workmanlike, sterling manner. Even the carriages of the last class are covered, and the sides protected by leather curtains—if such be necessary in that Ausonian climate. The prices are not higher than on the other Italian lines, and the road passes through all the luxuriant olive groves of the Lucchese. A person is now able, during one day's stay at Livorno, to pass a few hours at Lucca, and also at Pisa, and return in the evening to Civita Vecchia;—a *forced* way of travelling, it is true, but one in accordance with the rapid progress of our times. A steam communication between Livorno and Corsica has existed for some time past; and another with Elba is projected. The line to Florence progresses very slowly—which, however, is rather creditable to the Tuscan government, as the rural communities raise some objections to the intersection of their communal roads, and which the grand duke does not wish to cut through in an arbitrary manner.

Gold Mines on the Coast of Guinea.—The attempt to regularly work these famous mines has often been tried, but without any beneficial result; most probably arising from the climateric condition of the country; with which, however, our present hygiæcistic knowledge is more likely to cope successfully. The Dutch Government has now formed a new and systematic plan, and a person connected with the Colonial Office has visited Freyburg, for the purpose of engaging the most skilful miners. This has been effected, and the whole mining colony will immediately start for its destination.

Governmental Chemistry in Bavaria.—A society has been formed at Munich for the dissemination (not dif-*fusion*) of useful knowledge, under the presidency of the royal heir to the throne. The first work published by this society is a "Handbook of Chemistry," by Runge. A most novel plan has been adopted in this work—namely, to put chemical solutions and compounds, *in natura*, upon slips of paper, which, exhibiting all the variety of chemical colours, and being pasted beside the text, afford to the incipient chemist, and such as have no laboratory at their command, the very substance described and dilated upon, before his eyes; and which, in many cases, shows traces of crystallization, &c. The book exhibits, thereby, a very pleasing and varied appearance, and is, moreover, written with that simplicity and system, as to be intelligible to the capacity of every intellectual person—a merit more unusual than is generally supposed.

J. L——Y.

NOTES OF THE MONTH.

The Hall at Hampton Court Palace, known as Wolsey's Hall, has been re-opened to the public; having undergone a series of embellishments by Mr. Willement, which contribute to make it one of the grandest in Europe. The large windows, thirteen in number, on the north and south sides of the hall, have been filled with new stained glass, harmonizing with the noble windows at the east and west extremities. The compartments of the east and west windows are occupied by the arms of Henry VIII. and those of his house. The subjects of the thirteen new windows now added by Mr. Willement are the armorial pedigrees of the six wives of Henry VIII., alternating with the eight heraldic badges of the monarch—the Tudor rose, the *fleur-de-lis*, the portcullis, the red dragon, &c., within separate wreaths of foliage.

The *Globe* states that the Commissioners of Woods and Forests have resolved on carrying into effect the long-projected improvements in the vicinity of Buckingham Palace. In the course of the ensuing summer, various buildings, nearly opposite the equerries' entrance, are to be razed with the ground; and shortly after Midsummer, it is rumoured, Charlotte-street Chapel is to be taken down.

Mr. Dyce has been commissioned to paint, on the walls of the staircase at Osborne House, in fresco, on a large scale, an historical, or rather poetical, subject—"Neptune yielding to Britannia the Sovereignty of the Seas." The finished study for the picture has been submitted to Her Majesty and Prince Albert; who have expressed their satisfaction by ordering its immediate execution.

Cases have arrived in Athens containing the collection of casts taken from the bas-reliefs of the Parthenon, now in London—and which the British Government has presented to the Athenian Museum. These works of Art have been temporarily deposited in an ancient Turkish mosque; and will, in a few days, be ready for the admission of the public.

Royal Steam Navy.—It is in contemplation to appoint an additional comptroller of the steam machinery of the Royal Navy, and Captain Elise will have

the aid of a practical engineer in this department. Mr. Lloyd, chief engineer at Woolwich Dockyard, is named for the appointment of the steam machinery branch, with offices at the Admiralty. Mr. Rigby is appointed second assistant to the chief engineer at Woolwich Dockyard, the increase of the works requiring the addition of a second assistant to the department.

The Tubular Bridges.—The platforms and workshops required for the construction of the Menai and Conway bridges are in progress. The platform at the Menai Straits will be 1090 feet long. The works will be superintended by Mr. Edwin Clark, the resident engineer, whose assiduity and earnestness in the experiments and other labours connected with this undertaking have proved very valuable.

The New Planet.—Mr. Adams's mathematical investigations are now published as an apendix to the *Nautical Almanack*. A very clear paper on the subject of the controversy has recently appeared in the *Mechanics' Magazine*, under the title "Axoniensis," bu tthough the ability of the writer and his zeal in defence of our countryman's claims are deserving of great praise, we think that he has entertained the question somewhat too warmly. The priority of Mr. Adams's discovery is now established beyond dispute, and all further discussion should be maintained without even the appearance of personal recrimination. *Non tali auxilio tempus eget.*

Dr. Morse's System of Cerography.—By this invention a map may be drawn as quickly and as well with a pen and ink on paper, in a ground as thin and perfect as a common copper plate etching ground, and in a few hours, perhaps in a few minutes, obtain from it a type-metal plate, which shall print every point, line, and letter of the drawing under the common printing press as rapidly as newspapers or wood-cuts are printed. Several maps executed by Dr. Morse were upon the table, and for clearness and beauty far exceeded any wood engraving. In particular, the writing on the lines representing water, and which can hardly be done at all in wood, is effected in a manner little inferior to copper-plate. Already, in America, the discovery has been most extensively applied, putting the means of instruction into the hands of the many at the cheapest possible rate.—*Geographical Society, Jan.* 11.

An analysis of Bohemian glass, by Dr. Rowney.—This is the glass so valuable for its infusibility in the construction of the combustion tubes used in organic analysis. Although soda was found present to the extent of ¼ of the potash, the glass appears to be essentially a silicate of lime and potash, in which the oxygen in the silicic acid is to that in the bases as 6 to 1. It gave 73 per cent. silicic acid, 11½ potash, 3 soda, 10½ lime, with small quantities of alumina, peroxide of iron, magnesia, and oxide of manganese, to make up the 100 parts.—*Chemical Society, Dec.* 1.

COVENT GARDEN THEATRE.

We have had an opportunity of watching the progress of the alterations of this house, from the commencement of the works on the 3rd of December last to the present time, and have been surprised to see such a gigantic concern proceed with so much rapidity. During the two months the works have been in hand the whole of the interior of the theatre, from the ceiling to the foundation, has been taken down; two walls, varying from 3 to 4 bricks thick, and 22 feet high, have been carried up in cement from the foundation to support the front and back of the boxes, and on these walls are erected cast iron columns, 10 ft. 4 in. apart in front, and 11 ft. 6 in. apart at the back of the boxes, and 6 in. to 8 in. in diameter, from the level of the pit tier of boxes up to the ceiling, which support five tiers of boxes. Two new stone staircases, surrounded with brick walls, carried up from the level of the ground to the upper tier of boxes and gallery, have been built, and all the stone steps prepared, and the saloons, grand staircase, and the entrance halls and lobbies have been completely changed and re-constructed. When we tell our professional readers that these works have been executed within the short period of two months, out of which three weeks were occupied in pulling down the old interior, we think they will be surprised; and, we must observe, that all the works have been carried up in the strongest manner. We state this because a malicious report has been spread that part of the works had failed during the progress. This, we can positively state, is not the case. If there be a fault, it is that too much materials have been used; but when it is recollected the necessity of having a theatre constructed without vibration, this additional strength will not appear superfluous. The decorations will be superbly grand, and are commenced.

From our last view of the premises on the 28th ult., we have no doubt of the works being completed, with all the decorations, by the middle of March. Too much praise cannot be awarded to Mr. Albano for his persevering labours in directing the works and labours of from 600 to 700 men, constantly at work night and day.

During the progress of taking down the interior fittings, it was discovered that the plates, 9 inches by 6 inches, in the main wall of the building 4 feet thick, were entirely perished, although they appear to have been of sound Memel timber when put into the building. These timbers, to the extent of from 800 feet to 900 feet run, have been removed, and replaced with brickwork pinned in with cement. We firmly trust this will be a warning to architects against using large timber plates and bond timber in brickwork.

When the whole of the works are complete we will give our readers the detailed account of the extent of the works, to show what may be done by perseverance in a short period.

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM DECEMBER 31, 1846, TO JANUARY 21, 1847.

Six Months allowed for Enrolment, unless otherwise expressed.

Thomas Edge, of Great Peter-street, Westminster, gas-meter manufacturer, for "Improvements in the manufacture of gas-meters."—Sealed Dec. 31.

George David Myers, of Bridge-row, London, engraver and printer, William Cooper, of Saint Paul's Churchyard, bonnet manufacturer, and Thomas Wansbrough, of Southwark Square, Surrey, hatter, for "Improvements in the manufacture of caps, bonnets, book-covers, curtains, and hangings, show cards or boards, labels, theatrical decorations, and coffins."—Dec. 31.

William Knowleden, of Great Guildford-street, Southwark, engineer, for "Improvements in steam engines."—Dec. 31.

Stephen R. Parkhurst, of Leeds, York, manufacturer, for "Improvements in carding wool, cotton, and other fibrous substances."—Dec. 31.

Clemence Augustus Kurtz, of Salford, Lancaster, manufacturing chemist, for "certain Improvements in the mode of preparing and using indigo in the dyeing and printing of woollen, cotton, and other fabrics."—Dec. 31.

Adrien Chenot, of Clichy la Garenne, near Paris, for "certain Improvements in the treatment of metallic oxides and other compounds, and in apparatus for the same."—Dec. 31.

Charles Dowse, of Camden Town, Middlesex, gentleman, for "Improvements in applying springs to braces, to portfolios, to hats and caps, and memorandum and other books."—Dec. 31.

John Clegg, of Oldham, Lancaster, machinist, for "Improvements in looms for weaving."—January 7.

Moses Poole, of London, gentleman, for "Improvements in fish-hooks." (A communication.)—January 7.

Samuel Barrows, of Sheffield, York, manufacturer, for "certain Improvements in the manufacture of knives."—January 7.

Pierre Louis Thimote Thiers, of No. 40, Passage Choiseul, Paris, for "an Improved instrument for drawing off the milk from the breasts of women, and for raising and protecting the nipple both before and after childbirth."—January 7.

Charles Runhold Lethman, of Craven-street, Strand, chemist, for "Improvements in the manufacture of white lead."—January 7.

Joseph Benoit Pierret, of Old Compton-street, Middlesex, engineer, for "Improvements in steam-engines."—January 11.

John Chubb, of St. Paul's Churchyard, London, and Ebenezer Hunter, the elder, of Wolverhampton, Staffordshire, lock-makers, for "Improvements in latches, latch-locks, and other locks for fastening."—January 11.

Douglas Pitt Gamble, of Crouch End, Middlesex, gentleman, for "Improvements in electric telegraphs."—January 11.

John Platt, of Oldham, Lancaster, machine maker, for "certain Improvements in the method of consuming smoke and economizing fuel."—January 11.

John Britten, of Liverpool, Lancaster, chemist, for "certain Improvements in machinery or apparatus for printing, ruling, and damping paper for various purposes."—January 12.

Lionel Campbell Goldsmid, of Rue Mogador, Paris, Esq., for "Improvements in applying rudders to ships and other vessels." (A communication.)—January 14.

John Fray Poole, of Bolton-le-Moors, Lancaster, book-keeper, for "certain Improvements in machinery or apparatus for spinning cotton and other fibrous substances." (A communication.)—January 14.

Joseph Seraphin Faucon, of Rouen, France, banker, for "Improvements in the manufacture of soap."—January 14.

Alexander M'Dougall, of Longsight, Lancaster, gentleman, for "Improvements in the manufacture of glue, and in treating products obtained in the manufacture of glue."—January 14.

Stephen R. Parkhurst, of Leeds, manufacturer, for "Improvements in rotary engines." January 14.

Henry Grafton, of Holborn-hill, London, engineer, for "Improvements in railways wheels and apparatus connected with railway carriages."—Jan. 16.

Frederick Lesnard, of Chester-street, Kennington-lane, Surrey, engineer, for "Improvements in obtaining motive power."—Jan. 16.

John M'Intosh of London, gentleman, for "Improvements in rotary engines, and in moving carriages up inclines, and in propelling vessels."—Jan. 19.

John Read, of Regent Circus, Middlesex, mechanist, for "Improvements in certain implements in the cultivation of land."—Jan. 19.

Edward Vickers, of Sheffield, York, mechanist, for "Improvements in machinery for cutting files." (A communication.)—Jan. 19.

Towers Shears, of Bankside, Southwark, for "Improvements in treating zinc ores for the purpose of producing zinc ingots, which improvements are applicable to the production of other ores and metals."—Jan. 19.

Thomas Deakin, of Kings Norton, Worcester, engineer, for "Improvements in the construction and arrangement of machinery to be used in cutting, stamping, and pressing."—Jan. 21.

Thomas Onions, of Calais, France, engineer, for "Improvements in rotatory steam-engines."—Jan. 21.

George Beadon, of Taunton, Somerset, commander in the navy, and Andrew Smith, of Princes-street, Leicester-square, Middlesex, engineer, for "Improvements in warping or hauling vessels, which improvements are also applicable to moving other bodies."—Jan. 21.

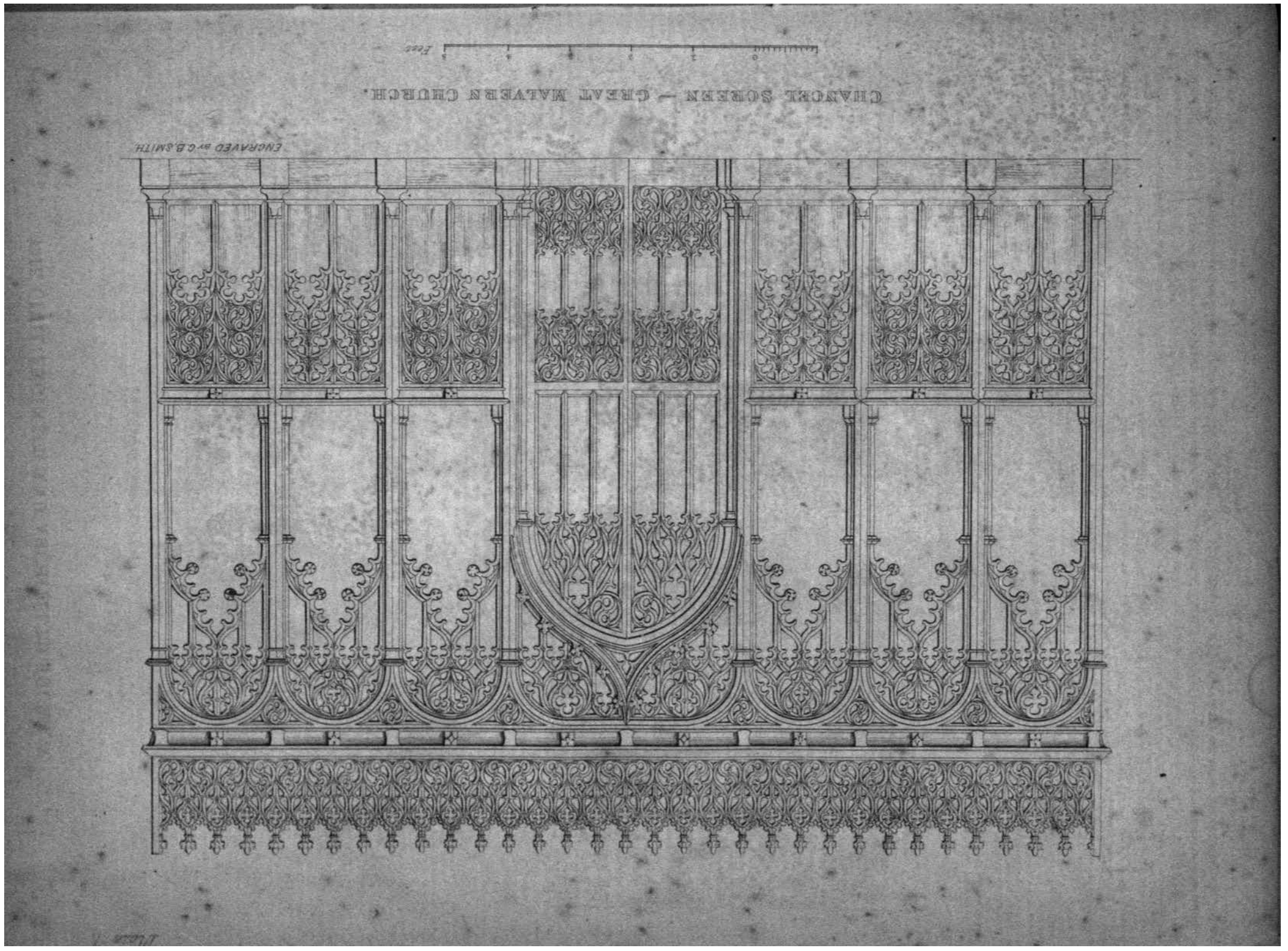
TO CORRESPONDENTS.

Sir Howard Douglas has sent a valuable paper on the Strength and Stability of Hungerford Bridge, which we regret being compelled to postpone till next month.

In reply to the inquiry respecting the dimensions of the model experimented upon at Millwall last month, we refer to the number for October 1846. The dimensions there stated were the same as in the recent experiments, except that the thickness of the bottom-plate which has no cellular compartments, was doubled for twenty feet on either side of the centre.

CHANCEL SCREEN — GREAT MALVERN CHURCH.

ENGRAVED BY C.B.SMITH



ARCHITECTURAL CARVING.

(With an Engraving, Plate VII.)

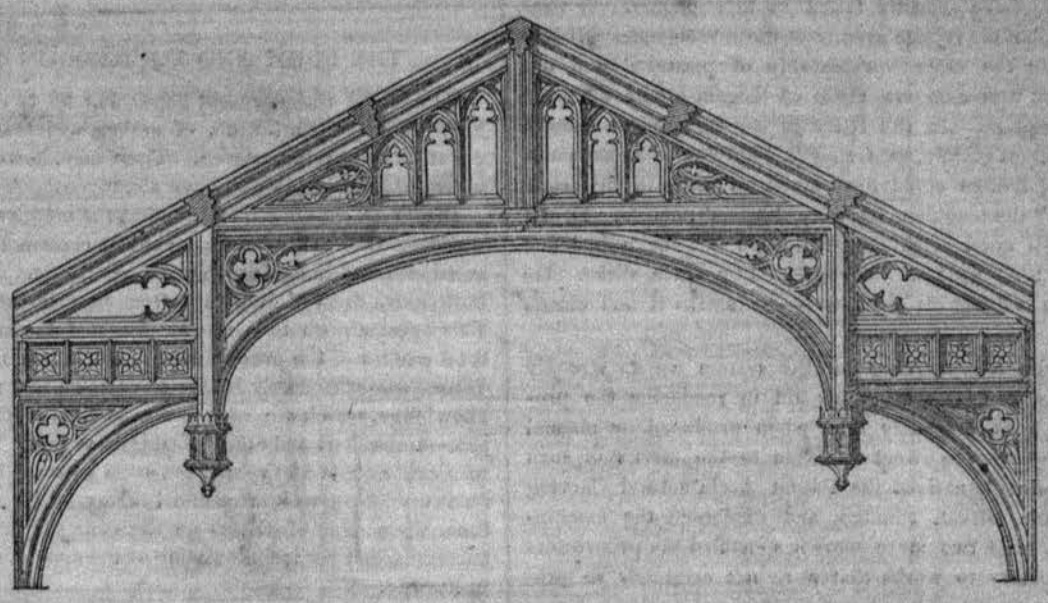


Fig. 1.—Roof of Ravensworth Castle Dining-Room.

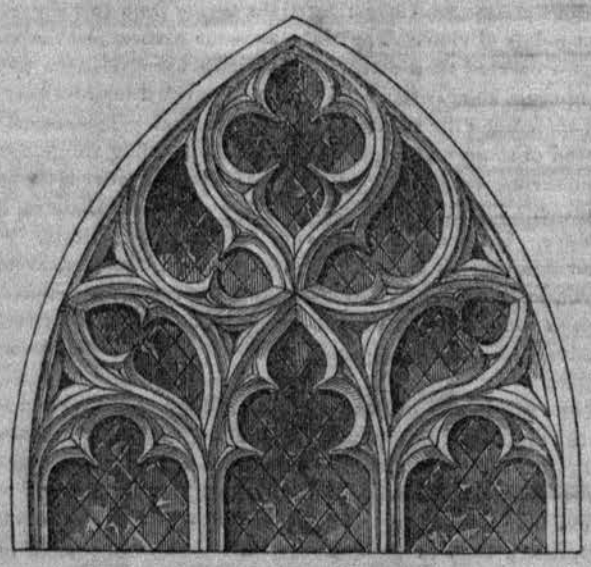


Fig. 2.—Stone Window—Carlisle Cathedral.

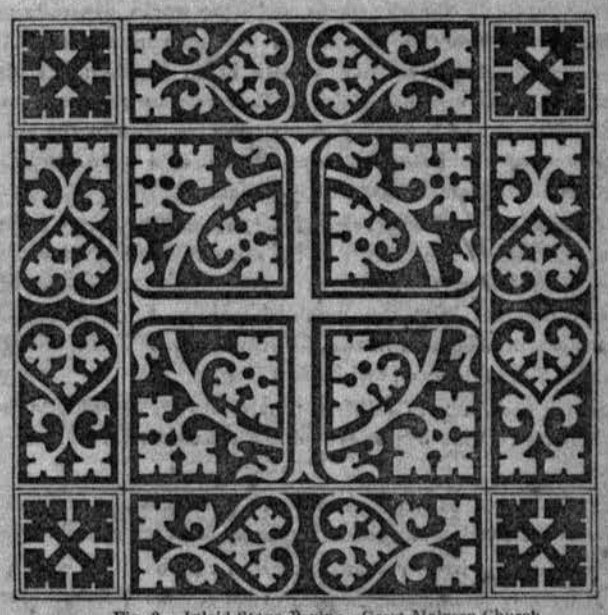


Fig. 3.—Inlaid Stone Paving—Great Malvern Church.

To our strong consistent advocacy of the introduction into architecture of real materials, which in modern times have been supplanted by counterfeit, one of the most obvious objections is—where is the money to come from to produce such an architectural effect as we are enabled to do by the aid of compo, papier maché, composition, and such productions? The ornamental work of the Italian façade architecture exemplifies the nature of the effect produced. Abstract reasoning is wasted on these reasoners: perhaps a reference to the practical effect of their doings may throw light on the subject. No doubt they succeed in producing a *momentary* effect on the spectator when the building is first cleared of its scaffolding,—but how long does cheap splendour last? Let the unbiassed spectator walk up Regent-street—Regent's-park—on the terraces at Brighton—and view the motley appearance of the buildings; some of one tint and some of another; one half of a pediment light stone, the other half a dark stone tint; the divisional line of two houses continued down to the ground through the blank windows, and half a column to each:—and let him take into account the weather-marks of the winter months, and the peeling off here and there of the dishonest integument, and he shall allow that these patches and stains are as motley as the rags of poverty,—it is but a beggar's dress which is held up for his admiration.

It is not to be inferred that, because we condemn the imposture when unsuccessful, we condemn it *because* it is unsuccessful. Deceit and trickery are not the less detestable because they are occasionally practised so well as to escape detection. These plaster-clad edifices have a multitude of faults besides the patchwork. To take one of the most practical arguments as most suited to the capacities of those who constitute our opponents—the stucco usually disguises wretchedly inferior brickwork, of bad materials imperfectly put together. The vile pretenders assume the appearance—the strength of stone masonry, while they have not even the ordinary stability of

brickwork. They are like the feeble beast in the fable, who indued himself with the skin of the lord of the forest.

Not unfrequently they are prostrated in ruin, the result of their own pretensions. Some of these vile showy structures in the new metropolitan streets have recently failed in this manner. We are not destructionists, but we rejoice greatly at the intelligence. If any one would compare the mere workmanship of plastered and unplastered houses, let him compare those of Regent-street with the adjacent Hanover-square. In the latter place, the honest homely bricks show themselves plainly, as if they had nothing to be ashamed of. But an honest builder could have taken no pride in his work when "running up" the neighbouring linen-drapers' palaces. Deceit begets dishonesty: a good bricklayer will soon become a bad one when he knows that his work will be concealed by white slime. He has no gratification in doing his work well—he shirks it and cheats his employer.

To assist the architect in carrying out the system we so strongly advocate, steam has been brought to his aid in rendering the productions of carved work less costly than when produced by manual labour. It is our intention to direct attention to the merits of such works. We have already noticed the Patent Architectural Carving Works, in Eccleston Street, Pimlico, and explained the machinery. The experience of two more years has enabled the proprietors to adapt the machinery to works that were not originally so produced. In the show-rooms may be seen architectural perforated pannelling for gallery fronts, parapets, ceilings, roofs, and wainscotting, lecterns, furniture, church screens, and other works, generally possessing the merit of correct design and perfect workmanship. One of these elegant screens we have shown in an Engraving (Plate VII). It has been lately erected at Great Malvern church, in the archway of the chancel, and is entirely executed in wainscot by the aid of the machinery of the Patent Carving Works, at a very small cost; its length is 16 feet, and height nearly 12 feet.

The annexed wood engraving (fig. 1) is another happy example of the application of the labours of the same Works; it shows the truss of an open timber roof, 30 feet span. There are eight of these trusses, together with the moulded purlins, ridge piece, cornice, rafters, &c., all executed in oak, for Ravensworth Castle dining-room. The roof is 30 feet span, and 70 feet long.

Another specimen, in a different material (fig. 2), exhibits the head of a window. This was executed in Caen stone, for Carlisle Cathedral.

Fig. 3 is a specimen of inlaid stone paving, which was also executed by the carving machinery for Great Malvern church.

The Company have recently executed various other works, among which we may mention the flooring of Sir Robert Peel's Picture Gallery, and a beautiful stone screen for St. John's Church, Stratford, in Essex, which has excited great admiration.

It will be seen from the drawings we have given, and the prices, that ornamental architectural works, of a highly ornate style, may be produced in real materials, at about the same price as the counterfeit, when we take into consideration the cost of staining or painting, graining, and so forth. Much may be done if the architect will devote his attention to the subject, and get rid of the prejudices which he has been led into by a false education;—let him well study *proportion*. More is produced by this in a public building than all your excresences of enrichments, which are too often applied as if the structure were intended to be the show-building of a plasterer or artificial ornament manufacturer.

NOTES ON ENGINEERING,

No. VII.

THE FORM AND EQUILIBRIUM OF ARCHES.

The object of the present paper will be to explain a few theorems respecting the equilibrium of arches, which are very simple, and of great practical importance. They may, however, be prefaced by a notice of the authors who have already written upon the subject.

It may be considered certain that the mediæval architects, notwithstanding their extraordinary skill in constructing arches and flying-buttresses, and in determining the position and dimensions of piers and buttresses, derived their rules from experiment, and not from theory. This opinion rests upon the authority of the most eminent architectural writers of the present day, among whom may be cited Professor Willis, who fortunately is able to combine two very different kinds of knowledge, which are both necessary for the examination of the subject—archæology and mechanical philosophy. Parent and De la Hire, who wrote about 150 years ago, seem to have been the first who endeavoured to give a mechanical theory of the arch; and since their time, the number of writers on the same subject has been extremely numerous, and has included some of the most eminent mathematicians in Europe.

It would occupy too much space to notice the labours of these authors, or even to enumerate their works. But a sufficiently distinct notion of them may be obtained by considering them divided into two distinct classes, who investigated the theory from two altogether different points of view. The first class—the earliest and the most numerous—directed their attention chiefly to the conditions to which the component stones of an arch must be subjected in order that they may not *slide* upon the surfaces of mutual contact. The second class consisted of those who neglected this idea of sliding altogether, and confined themselves to the conditions necessary to prevent the joints from *opening*. The first class includes the names of Couplet, Bernouilli, Belidor, Coulomb and Bossut, continental writers, who have been followed by Hooke, Gregory, Hutton, Emerson, Whewell and Gwilt, in this country. Many of these writers have considered the arch as composed of perfectly smooth voussoirs, and sustained independently of friction—in this condition the arch is said to be "equilibrated."

Now this theory of the arch, though long in vogue and sanctioned by the highest authority, has been found practically insufficient for the purposes of the engineer. As a matter of fact, the voussoirs of arches have always so great friction that they never slide upon each other. The old theory, therefore, speculated about an accident which experience showed to be never likely to occur. Consequently the investigations, though frequently exhibiting extraordinary mathematical research, and leading to very beautiful results, could scarcely be of any direct value to the practical engineer; and accordingly, a writer, who has taken the highest position in this country for his practical applications of mechanical principles—Professor Moseley, has in his writings entirely excluded the speculative investigations just mentioned, and has confined his attention to the statical conditions necessary for preventing that accident which may and does occur—the opening of the joints.

In this pursuit we shall endeavour to follow him. It has unfortunately happened that though his principles are characterised by extreme accuracy, the results are frequently too complicated to be of value to an engineer. Now what will be here attempted, is to establish a few general propositions which are frequently unknown or misapplied, and to give some methods by which the form and thrust of arches may be calculated,—not with anything like the generality and precision studied by Professor Moseley, but with accuracy quite sufficient for ordinary purposes, and with perfect facility of computation to all who are acquainted with common arithmetic.

There are three conditions to be considered as affecting the equilibrium of the arch—1st. The form and dimensions of the *intrados* or internal lower curve of the arch: 2nd. The form and dimensions of the *extrados* or external curve of the arch: 3rd. The weight and disposition of the loading. The first condition of courses includes the rise and span; the second, combined with the first, is equivalent to a determination of the depth of the voussoirs; the third exhibits the external forces to which the system is subjected: for we suppose that not only is the weight of the loading known, but also the manner of its distribution—that is, whether and in what degree its specific weight or density varies in different parts of it.

But, it may be asked, is not this enumeration of the conditions of equilibrium imperfect from the omission of the form, number, and position of the joints? The answer to this question is important, because it exhibits in the strongest light possible the distinction between the ancient and the modern theory of the arch. It is manifest that the extrados and intrados, which have been enumerated as two of the "conditions," simply define the depth of each voussoir and the form of its upper and lower curved surfaces: the lateral dimensions of the voussoir, and the form of those surfaces of it which are in contact with the adjacent voussoirs, are as yet left indeterminate. Consequently it is not known how many joints there be, or even whether there be any joints. Neither is the direction of the joints ascertained; they may be plane converging joints, or they may be "joggled," or all vertical, or all horizontal—(as an instance of the latter case may be cited the Treasury of Atreus at Mycene, where the stones are not wedged together, but are merely disposed in horizontal courses, each *resting* upon and over-lapping that beneath it, the whole being hewn in such a form as to give the structure the appearance, but not the mechanical properties, of a dome).

It is as well to consider these objections *in limine*. The answer then is this. The theory which Professor Moseley has exclusively, and Professor Whewell and other writers partially, adopted, and which we are endeavouring to set before the reader in a new form, presupposes that the stones are sufficiently cuneiform to be incapable of sliding past each other: but further than this no consideration is paid to the form of the bed-surfaces. The mutual friction of the voussoirs is so great, that there is not the least difficulty in so shaping them, that the arch shall not fail by their sliding past each other—that accident, as has been said, is never known to occur. So that the precautions under this head being perfectly obvious, the theory does not at all deal with them, and, as we shall see further on, is independent of the form and direction of the joints—or to speak more precisely, the theory shows how to ensure the stability of the arch, whatever may be the inclination of the beds, &c., however numerous, or however few they may be; so that the structure should stand even if intersected by infinite number of joints running in every possible direction—provided always that they were sufficiently convergent or joggled, so that the voussoirs could only fail, if they did fail, by opening, and not by slipping.

The reader who approaches the subject for the first time will not perhaps perceive at once the full effect of these observations. But his attention is now directed to them, as he will be left hereafter to apply them for himself to the cases particularly discussed. Returning now to the three "conditions" which have been enumerated, we find that they give rise to four distinct problems—three of the problems arise from combining any two of the conditions as data to find the third, and the fourth problem arises from the combination of all three conditions considered as known data. The four problems are these—

1. Given the distribution of the loading and the intrados to determine the extrados proper for stability.
2. Given the distribution of the loading and the extrados to determine the intrados proper for stability.
3. Given the extrados and intrados to determine the distribution of the loading proper for stability.
4. Given the extrados, the intrados, and the *amount* as well as distribution of the loading to find the consequent horizontal thrust of the arch.

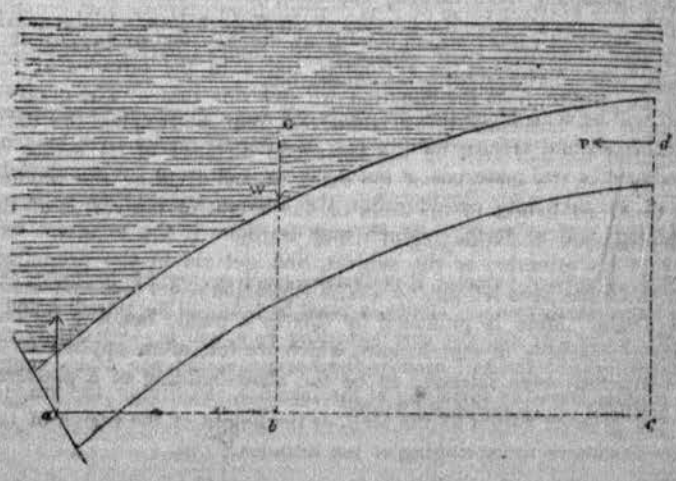
It will be observed that the absolute weight of the loading is taken into account in the fourth problem only: in the other problems the *relative* weight is alone considered; in other words, the form of the arch is connected not with the actual amount of the external forces, but with the relation or comparative amount of those forces, as they vary in different parts of the structure. It may perhaps be as well to recollect that in this respect there is an analogy between the arch and the other two contrivances employed for spanning the interval between piers or abutments—namely, the catenary and the girder. For respecting the catenary, it is known that if a heavy cable and a fine thread, both of the same length, span the same distance, they will assume the same form: and this similarity of form will be observed either when the cable and the thread are each of uniform thickness throughout its length, or when (the thickness not being uniform) the law of variation is the same for each. Also the form of the girder of uniform strength, or the variation of the sectional dimensions of a girder that it may be equally strong in every part, depends not on the actual amount of the load, but on its distribution or comparative weight in different parts. This digression will not appear superfluous when it is considered how much the physical conception of a subject like the present is cleared by a distinct apprehension of its relations to kindred subjects.

We shall take the fourth problem first, because it is the simplest. Here, however, as elsewhere, it is simply intended to show how much may be done by very simple calculations—the discussion of the problem in all its generality, and with perfect accuracy, will not be attempted.

Thrust of Arches.

The thrust or horizontal pressure of the arch tending to push its abutments outwards is the distinguishing characteristic of that structure. This kind of force does not exist in the other contrivances for spanning the intervals between abutments. The suspension chain, attached at its extremities to the summits of two towers, exerts at those points a horizontal force *inwards*, equal to the tension of the catenary at its lowest point. In the beam or girder, the forces of tension and compression are equal and opposite, and there is, therefore, no external horizontal force on the abutments.

The following method will explain the cause of the horizontal thrust of the arch, and serve in estimating its amount. Let the accompanying diagram represent the half of an arch, and its own load considered as a separate statical system. And to make the case simpler, let us suppose the load on the half arch sustained entirely by it, and not supported in any way by the contiguous portions of loading on either side of it, which are supposed to be removed. The half-



load here represented will not, in that case, have any external force acting upon it to modify the effect of its weight on the half arch.

Let it also be supposed that the half arch removed had the effect of exerting on the half arch represented certain pressures, of which the resultant is a force P, acting at some point *d* in the crown. P will be wholly horizontal, if the two halves of the arch be similar and similarly circumstanced. For, if every part of their mutual pressure were vertical, it must act upward on one half arch; and in the opposite direction, or downwards, on the other half arch. And this is evidently inconsistent with the hypothesis that both half arches are similarly circumstanced.

The other forces of the system are its pressures upon its abutment. These pressures will have a single resultant, acting at some point, *a*: and by equating the vertical and horizontal forces, it follows that the components of this resultant are an upward vertical force equal to the weight of the system (W), and a horizontal force equal to P, but contrary in direction.

Now, the tendency of the weight W to turn the half arch about the abutment may be considered the cause of the force P at *d* being called into existence. As no horizontal forces but those mentioned are supposed to act, the horizontal force P exists in every part of this arch.

Draw *a c* horizontal, and G *b* vertical from G the centre of gravity of the system: this latter line is that in which the weight of the system acts. Draw also *c d* vertical.

The vertical distance of the upper force P from *a* is equal to *c d*, and the horizontal distance of the force W from *a* is *a b*. The moment of P about *a* is therefore $P \times cd$, and that of W is $W \times ab$: these moments are equal to each other.

$$\therefore W.ab = P.cd, \text{ or } P = W.\frac{ab}{cd}.$$

If, therefore, we knew the exact value of *ab*, *cd*, and the total weight W, we should be able to get P at once from the above simple equation. But, in fact, we do not know the exact point *a*, which is the point of application of the resultant of the forces at the springing; neither have we ascertained the exact point *c*. All we know of either point is that it is somewhere between the extrados and intrados at the springing and vertex respectively.

It is not necessary, however, for our purpose to define either point for the limits assigned for its position are generally small enough to define P from the above equation with sufficient accuracy for pr ctical purposes. By referring to the equation, it will be seen that the *greatest* value of P is derived from giving *a b* its greatest, and *c d* its least, possible value: and conversely, the *least* value of P is derived from giving *a b* its least, and *c d* its greatest, possible value. The real value of P lies between these limits.

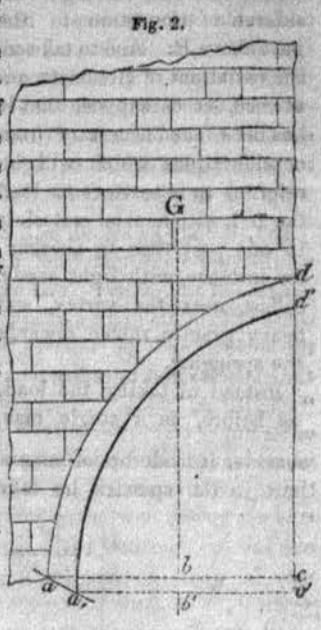
1st. The greatest value of P is derived from giving *a b* its greatest and *c d* its least value; which conditions are satisfied by supposing *a* to be in the extrados at the springing, and *d* in the intrados at the vertex. Hence, from the equation we get this rule—"The greatest value of the horizontal thrust is derived from multiplying the tota weight of the half arch by the horizontal distance of its centre o gravity from the springing of the extrados, and dividing the product by the *least* height of the arch, or the height of the vertex of the intrados above the springing of the extrados."

2nd. The least value of P is derived from giving *a b* its least, and *c d* its greatest, value. Hence, *a* must be taken in the intrados, and *d* in the extrados; and the corresponding rule will be—"Multiply the otal weight of the half arch by the horizontal distance of its centre of gravity from the springing of the intrados, and divide the product by the *greatest* height of the arch, or the height of the vertex of the extrados above the springing of the intrados."

Having obtained these rules we may proceed to practical illustrations of them. It may however be first observed that their accuracy depends entirely on the supposition that the half arch does not sustain horizontal pressures from the effect of the loading: if it did, the horizontal thrust P at *d*, would no longer be equal to the P at *a*, fig. 1.

Let us take the case of a half arch, *a a' d d'*, supporting a mass of masonry above it, as in the accompanying figure 2. This would be the case of a gate-entrance, or arch beneath a tower. If the tower be lofty compared with the rise of the arch, we may suppose G the centre of gravity of the half load centrically situated. This hypothesis saves the trouble of calculating the position of the centre of gravity of that part of the masonry which is situated in the spandril of the arch: the *weight* however of that portion must be included in the total load W; taking G in this position, then the rest of the calculation is very simple. Draw the vertical line *b b*, indicating the direction in which W acts. Then, as we have already shown, the greatest and least values of the horizontal or lateral thrust are respectively,

Fig. 2.



$$W \times \frac{a\,b}{c\,d'} \text{ and } W \times \frac{a'\,b'}{c\,d'}.$$

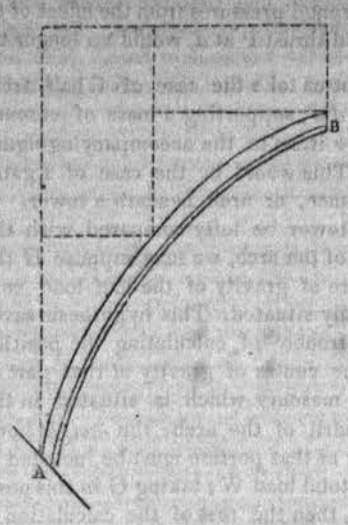
Suppose, for example, that the weight of the masonry W is 20 tons; that by measurement *c d'* the least rise of the arch = 8 feet, and *a b* = 4 feet, (the span of the arch being about four times as much), then we get immediately the greatest value of the thrust = 20 tons $\times \frac{4}{8}$ or = 10 tons. And suppose it to be also found by measure that *c' d*, the extreme rise, is 9 feet, and *a' b'* = $3\frac{1}{2}$ feet, then the thrust = 20 tons $\times 3\frac{1}{2} \div 9 = 7\frac{7}{9}$ tons.

Now it will be observed that between the greatest and least value of the thrust so obtained ($7\frac{7}{9}$ and 10 tons), there is a considerable discrepancy, namely, upwards of two tons. But it is to be remembered, that methods here explained, though founded on exact principles, are merely approximative; and, moreover, we have purposely chosen a much more unfavourable instance than will generally occur in practice.

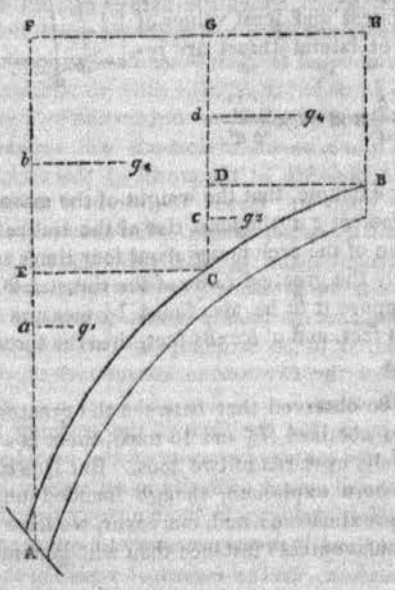
In making a section, as in the above figure, dividing the arch and its loading into two parts, it is virtually assumed that the part of the loading which is represented in the figure is not subject to forces arising from its connection with the part supposed to be removed. That, in general, this hypothesis is nearly correct, will be allowed when it is considered that the masonry of the superstructure is laid on gradually in successive horizontal courses, and that each stone is supported in its place by those below it, and has no tendency to roll over or move sideways. Where the workmanship is accurate, there will be little strain between the two halves of the load, except from "settling" or similar accidental causes, the nature of which precludes specific calculation.

The above method of determining the thrust cannot apply except when the form of the structure is such as to allow of a tolerably accurate guess as to the position of the centre of gravity of the load sustained by the half arch. This can only be made where the specific gravity of the loading is uniform, and the structure is so lofty compared with the rise of the arch, that the mass contained in each spandril is too small to materially affect the centre of gravity. Where, however, the rise of the arch is considerable compared with th dimensions of the superstructure, we may resort to the following method, which will be found very convenient, and which will have the advantage also of determining the thrust when the loading is heterogeneous.

Let A B F H represent the vertical section of the half arch; the part of the load below B (in the spandril) bearing a considerable proportion to the part above B. And to take all the variations of circumstances at once, let us suppose that it has been found necessary (from considerations which will be referred to hereafter) to load the arch with heavier materials in one part than in another; for instance, with light sandy ballast near the vertex, and heavy granite rubble towards the springing.



Instead of taking the load, as before, as a single mass, consider it made up of several portions, as in the figure. Let the part in the spandril be taken as two (nearly) triangular masses or



prisms, A E C, C D B. The forms of the rest of the loading will depend upon the nature of the superstructure. But where the upper line, F G H, is a horizontal straight line, we may consider the rest of the loading as rectangular masses, E C G F, D G H B.

One of the advantages of this hypothetical division of the loading is that it enables us to estimate the effect of variations in the density of the ballast. For example, A E C may be one kind of ballast, C D B a second, E C G F a third, and D G H B a fourth. The first operation in the calculation will be to find out the weight of each portion as nearly as possible. This will easily be done (the form of the arch and superstructure being already determined upon) by estimating the cubic content of each portion, and multiplying this quantity by the weight of each cubic foot of the material employed. It is scarcely necessary to observe, that the weight of the voussoirs themselves must be included in the lower or triangular portions.

The weights being found, there will be very little difficulty in ascertaining their effect or moment in producing the thrust. Let g be the position of the centre of gravity of the lower triangle. By a known property of the centre of gravity of triangles, $a g_1 = \frac{1}{3}$ E C. Now, $a g_1$ is equal to the horizontal distance of the centre of gravity from A, and therefore determines the moment. Hence the weight of the triangle A E C, multiplied by $\frac{1}{3}$ E C, is the moment of that portion about A.

Similarly, in the triangle C D B, if g_2 be the centre of gravity, $c g_2 = \frac{1}{3}$ D B. Therefore, the horizontal distance of g_2 from A is E C + $c g_2$: the moment of the triangle C D B is, consequently, its weight multiplied by (E C + $\frac{1}{3}$ D B).

The two parts E F G C and D G H B, being rectangles, their centres of gravity may be considered as situated in the centres of those figures. Consequently, $b g_3 = \frac{1}{2}$ F G; and $d g_4 = \frac{1}{2}$ G H. On the whole, then, if we call the first mentioned weight W_1; the second third, and fourth, W_2, W_3, W_4, respectively, we have for the sum of, the moments, the expression

$W_1 \times \frac{1}{3}$ E C + $W_2 \times$ (E C + $\frac{1}{3}$ D B) + $W_3 \times \frac{1}{2}$ E C + $W_4 \times$ (E C + $\frac{1}{2}$ D B)

Adding these moments together, and dividing by the height of the arch, the result or quotient is the amount of the thrust.

This method, like the one first explained, merely suffices to indicate the limits within which the value of the thrust lies. There will be, as before, a maximum and minimum value, but the difference between them will be very small, except where the voussoirs are of great depth compared with the other dimensions of the arch. The maximum will be determined by estimating the horizontal distances of the weight from the springing of the extrados, and by giving the rise its least value, namely, the vertical height of the vertex of the intrados above the springing of the extrados: and conversely, for the minimum value of the thrust, the horizontal distances of the weight must be measured from the springing of the intrados, and the rise must have its greatest value, namely, the vertical height of the vertex of the extrados above the springing of the intrados. With these limitations, the following is the general rule for calculating the thrust:—"Consider the loading as composed of triangular and rectangular portions. Multiply the height of each portion by the horizontal distance of its centre of gravity from the springing. The sum of the products divided by the rise of the arch gives the value of the horizontal thrust."

To take an instance in illustration of the rule, suppose that in the last figure, the rise of the arch is 19 feet, and E C = 6 feet, and D B also = 6 feet, in this case the rise of the arch will be about 9 feet less than the span. Also let $W_1 = 4$ tons, $W_2 = 3$ tons, $W_3 = 6$ tons, and $W_4 = 5$ tons. The moment of W_1 will be $4 \times \frac{1}{2}$ E C = 8. The moment of W_2 will be $3 \times$ (E C + $\frac{1}{2}$ D B) = 24. The moment of W_3 will be $6 \times \frac{1}{2}$ E C = 18. The moment of W_4 will be $5 \times$ (E C + $\frac{1}{2}$ D B) = 45. The sum of these moments is 95, and this quantity divided by 19, the rise, gives 5 tons for the value of the horizontal thrust. If the above admeasurements be supposed to correspond to the maximum value of the thrust, a second calculation must be made, as above explained, with the admeasurements corresponding to a minimum value. The true value will lie between these two results.

Of course, where further accuracy is required, the load in spandrils may be considered as divided into three or more triangular portions, with as many rectangular portions above them. As the divisions are perfectly arbitrary and hypothetical, they may not only be of any number most convenient, but also the intersecting lines may be taken wherever they afford the greatest facility of calculation. In a four-centred arch, for instance, a vertical division may be made where the segment of short radius ends and the segment of large radius begins: or if there be an abrupt change from a heavier to a lighter loading, the vertical line at the place of change may be adopted in the calculation.

It must be carefully borne in mind, that the whole of these investigations presuppose that the only external forces are vertical weights. Where the loading rests firmly on the arch, and has no tendency to slide down the side of it, the hypothesis is strictly true; but in the case of a series of arches, as in bridges, the spandrils which adjoin at each pier are filled up simultaneously by throwing in the ballast, till it reach the intended height of the roadway. In this case it is clear that unless the ballasting were rammed hard, or concreted, the removal of the portion in one of these spandrils would cause the portion in the other spandril to slide down. Here, it is obvious that the two portions of the loading exert a mutual horizontal pressure, by which each prevents the other from slipping. This horizontal pressure must, in considering the equilibrium of each half arch separately (as

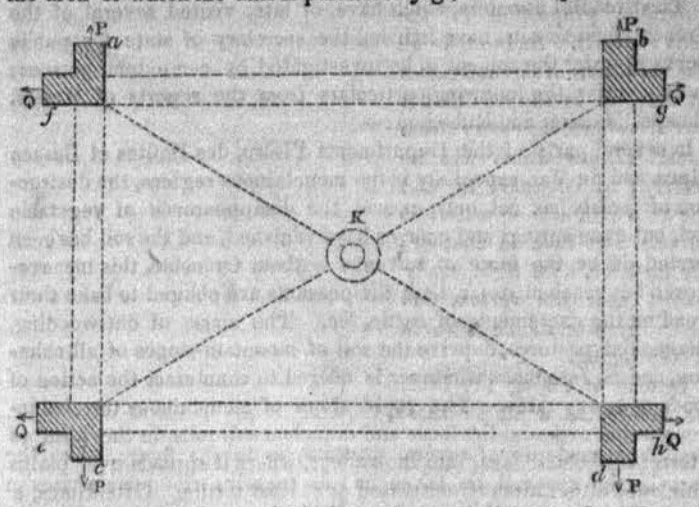
has been done above), be reckoned among the external forces of the system. The thrust of the arch is uniform in every part of its haunches where there are only vertical forces. But were the horizontal external pressures just alluded to exist, the thrust of the arch will be greater at the crown than at the abutments—being greater than we have calculated it at the crown, and less than we have calculated it at the abutments. It seems impossible to calculate the amount of this alteration, for to ascertain it we must know the mutual pressures of the contiguous portions of loading, the friction of the materials, and the degree of cohesion produced by ramming or settling—effects utterly beyond calculation. It may be observed, however, the ballast will generally be so firmly compacted that the part of each spandril, even if unsupported, would in most cases have little tendency to slide: and therefore where this precaution is used, the above methods will answer all practical purposes.

Sometimes the voussoirs of two arches, which spring from the same pier, do not rise independently, but are built together, and press upon each other at their extradosses for some distance as they rise together from the pier. It is clear that for the purposes of our calculation, the springing of each arch must be reckoned to commence from that point where the adjacent arch ceases to affect it. Wherever the spandrils of the contiguous arches are connected near their springing by small inverted arches (as in Blackfriars bridge), the modifying effect of these subsidiary structures must be taken into account. The thrust in such cases can only be reckoned for that portion of the main arch which is not affected by the contiguity of the other arches.

The general conclusion from the above reasoning is, that the smaller the rise of the arch in comparison with its width, the greater *cæteris paribus* will be the lateral thrust (of course these conclusions cannot be applied to the platebande or flat arch, where the depth of the voussoirs is so great, compared with the other dimensions, that the methods given above are totally inapplicable). As instances of this truth, may be cited the lofty Pointed arches of cathedrals, which frequently sustain enormous weights without exerting great lateral thrust. But it may be as well to refer, in passing, to an erroneous notion which is frequently entertained, that because high Pointed arches *can* sustain great weights, they therefore *ought* to do so for the sake of their stability. An idea of this sort is expressed in Pratt's Principles of Mechanics, and is supported by very confused and perfectly inapplicable reasoning: as has been already said, and will be proved hereafter, the form of the arch depends not on the amount of the loading, but on the distribution of it.

To return from the digression—we easily see that the limiting cases of the general conclusions just stated respecting the thrust of the arch are these.—If the arch were quite flat (the voussoirs not being of appreciable depth), a finite load would produce an infinite lateral thrust: again, were the arch so lofty that its span could be considered inappreciable in comparison with its rise, the greatest load would produce no horizontal thrust at all. In fact, this last hypothetical case is equivalent to that of a weight sustained by vertical posts or columns.

The consideration, that the thrust of the arch depends only on the rise and span—that the form does not affect the thrust (except indirectly, by influencing the position of the centre of gravity of the load), forms an appropriate introduction to the investigation of the lateral pressures of groined vaulting. In plain cylindrical arches, the thrust determined above is distributed in lines parallel to the axis of the arch throughout the whole of the springing. Consequently, it acts on the piers of a bridge (to take an instance) along a surface of which one of the dimensions is the breadth of the roadway, and may in general be considered as uniformly distributed. But if we take the case of double or intersecting groined arches resting, as supposed in the following diagram, on four detached piers, the amount of surface over which the thrust will be distributed is diminished with the diminution of the horizontal dimensions of the piers. In this case also the double arch will exert a double set of thrusts. Supposing the plan a rectangle, and that the arches and the distribution of the loading are perfectly symmetrical. Let $a f$, $b g$, $d h$, $c e$, be the four piers, and K the keystone or boss. Also let P be the thrust arising from the arch of which the axis is parallel to $f g$; and let Q be the thrust



arising from the arch of which the axis is parallel to $c d$. We may suppose that the forces at a, b, c, d, are all equal to P, and the forces at e, f, g, h, are all equal to Q, since we have supposed the two halves of each arch to be under exactly the same circumstances.

Now, if we take moments about $a c$, for the half arch, of which the axis is parallel to $a c$, no other moments will appear in the equation but that of the pressure at the crown of this arch, and that of the weight resting upon it. Hence the strain P is determined by the rules already laid down for single cylindrical arches—that is, it is equal to the moment of the weight divided by the rise of the arch. In the same way is the pressure Q determined. And hence we arrive at the conclusion, that the total pressure on any one of the four piers, may be considered to be made up of two component forces,—the thrust of each of the two arches considered separately and independently of the other.

It may so happen that the form of the groining materially affects the position of the centre of gravity of the loading. There will not however be generally much difficulty in estimating the moment of the weight by methods analogous to those already described.

This is as much as it seems necessary to say at present respecting the thrusts of arches. Of the means of resisting those thrusts, or of fixing the dimensions of the buttresses or piers which sustain them, mention will be made hereafter. In conclusion, it may be observed, that though these methods are confessedly approximative, they appear quite as much entitled to confidence as others of a more elaborate nature. M. Garidel has, with wonderful ingenuity and labour, formed tables of the thrusts of arches (*Poussees des Voutes*), calculated from a long mathematical formula, analogous to that arrived at by Prof. Moseley. Respecting, however, all long mathematical formulæ applied to practical mechanics, we are convinced, from considerable experience, that the following strictures are correct—first, these formulæ are too difficult to be employed by the engineer; secondly, if he could employ them, it would not be worth his while to do so—for they generally neglect some practical circumstance which entirely destroys their accuracy. In the case, for instance, of M. Garidel's tables and Prof. Moseley's formulæ, both proceed on the supposition that the materials of the voussoirs are perfectly unyielding and mathematically adjusted. If, by the slightest settling, the point of application of the resultant of the forces at the crown and springing be altered, the whole investigation fails. It is also obviously impossible to estimate rigorously the effect of the cohesive forces between the contiguous portions of loading resting on a series of arches; and the heterogenity of the materials is an insuperable obstable to any but approximative calculation.

H. C.

ON THE DESTRUCTION OF MOUNTAINOUS FORESTS AS THE CAUSE OF LATE INUNDATIONS.

The dreadful disasters which have, of late, visited several of the French Departments, have induced the secretary of state for public works to order the subject to be investigated by competent persons; and we derive the following particulars from the reports of Messrs. Blanqui, Maunier and Rubichon:—

In several parts of the Departments d'Isère, des Haûtes et Basses Alpes, and du Var, especially in the mountainous regions, the destruction of forests has not only caused the disappearance of vegetable fuel, but even springs and courses have vanished, and the soil has been carried off by the force of torrents. About Grénoble, this inconvenience has reached so far, that the peasants are obliged to bake their bread on the excrements of cattle, &c. The abuse of out-wooding, tillage, and pastures, deprive the soil of mountain-slopes of all cohesion, and no resistance whatever is offered to counteract the action of floods or heavy rains. The rapid slope of mountainous terrains increases this evil, and the loose and detached soil rolls, in the form of a torrent of black lava, into the valleys, where it spreads over plains which are either already cultivated or at least fertile. Oftentimes, a whole mass of earth is thus detached from a mountain, which thereby becomes visibly indented. Nothing can equal the scene of such terrible irruptions. Immense beds and layers of pebbles and débris, to the depth of many yards, cover the plains, and neutralise and destroy for ever the fertility. Trees and other vegetation vanish under the pressure of these débris; and the beds of rivers and streams, gradually heightened, reach at last the piers of the bridges, which are carried away.

Such are the effects of out-wooding a terrain. And as the forests consist, in the above-mentioned parts of France, merely of underwood, and are generally composed of fir (coniferous) trees, which do not grow again from their roots when once cut, the evil will become irrecoverable if no remedy be devised for it. In several localities, not a tree has been left; and as the peasants, therefore, have recourse even to the shrubs and brambles, M. Blanqui thinks that, fifty years hence, France and Piedmont will be separated from each other by a desert, as in the case of Egypt and Syria!

The diminution of springs and sources is seriously felt in the Departments of the Basses Alpes and du Var, in some of whose ravines and slopes all vegetation has also vanished. If a gale floods such localities, torrents sweep these desolated places, which neither cultivate nor fertilise them. As population increases and accumulates in other places, even the steep slopes of mountains are put under tillage, which still more augments the existing evil. The measures which have been hitherto resorted to, to bar these inundations, are—says M. Blanqui—both inefficient and unsystematic. The owners of the lands on the banks of rivers and torrents quarrel and litigate, instead of combining against the common enemy. Nothing can be more strange than the aspect of these isolated, ill-concerted works—here and there an embankment, a wall of piled-up stones, a coffer-dam of wood, or some patches of masonry. M. Blanqui thinks that none but government, aided by the combined efforts of accurate surveys and scientific systematic construction, can properly stay these yearly-increasing devastations: as, both for the re-plantation of out-wooded terrains and the embankment of the rivers, the skill and capital available by private persons, will ever be insufficient.

In the Pyrenees, also, the out-wooding of terrains, inundations, and scarcity of crops, have gone hand in hand. The area of forests which belonged to the crown, at the end of the sixteenth century, was equal to 250,000 hectares, which, in 100 years, was reduced *one-half;* and, at the end of the last century, amounted merely to 40,000 hectares. The out-wooding of private forests has been on as great a scale as those belonging to the crown. Thus, the outskirts of the Pyrenees, which once yielded a superior kind of timber for naval and structural purposes, are now scarcely sufficient to supply to the inhabitants the necessary quantity of fuel. Tillage has also been carried out to a senseless degree; and after the slopes have been put under cultivation, even the very crags of the mountains are taken possession of;—and here also, every inundation, however slight, sweeps all traces of vegetation and soil into the bed of the Garonne, and the Mediterranean.

We broach this subject the more eagerly, as ample allusion has been made thereto in the "Atti dei Scienziati d'Italia," Florence, 1844, 4to.—whence it appears that the same causes, and the same punyness and insufficiency of remedies, exist in nearly all the mountainous parts of the Italian peninsula.

J. L——y.

ON THE PHYSICAL IMPROVEMENT (ATHLETISING) OF ARTISTS.

"Mens insana—sini corpore sano."

History ought to be, and can be, the teacher of every one—not merely the warrior and statesman, but of *every one;* for history does not comprise merely the fates of such men, but of *all men.* We do not think that our "young architects" (artists) have ever directed their thoughts to those unobtrusive, but unrepudiable lessons and hints, which history has so extensively placed before them. Let us not speak of Greece and Rome—where it is known that even Plato *danced* at some public festive games; but come point blank to those prototypes of modern art. Where was Raffaelle born—how did he pass his earlier years? Why, his cradle stood on one of the most commanding situations of the Appennines, and in youth he became a wanderer to and fro Urbino, and to and fro a host of monasteries and castles—where he saw *nature,* men, and manners. But we will at once transgress to the putting down an axiom: "that there never was a great man, whose bodily and physical powers were not adequate to the part he had to perform." Sir Christopher Wren, who would have been considered nearly worthy of apotheose in former times, attained the age of ninety-two;—no bad proof, indeed, that he must have been a man of pith, stamina, muscle, and nerve. And again, to transgress from artists to all kinds of men,—Sir John Herschel and James Watt both attained the age of eighty-four; the former a *wanderer* as well—and a soldier to boot. Most of this class of people, when young, had neither carriages nor railways at their command; and wherever they wanted to go, they had to go *per pedes Apostolorum.* Take, therefore, the journeys of Raffaelle amidst the hills and dales, the forests and bushes, and the freshness and the sun of the Appennines, and that of many—nearly all—of our young men now. Born in Chancery-lane, or the Bull Ring at Birmingham—with a view on some ricketty, lumbery, smoked, brick casement. When children, walking down this street and another; and when young men, loitering from a musty, dark, cheerless office in Fleet-street, to the coffee or eating house; and so on. The greatest feat they may subsequently perform, is to go *on business* to Manchester or Liverpool—stowed in the wooden case of a railway carriage.

"Their is a life for you—
This is what you call life!"

makes Goethe exclaim Faust under nearly similar circumstances.

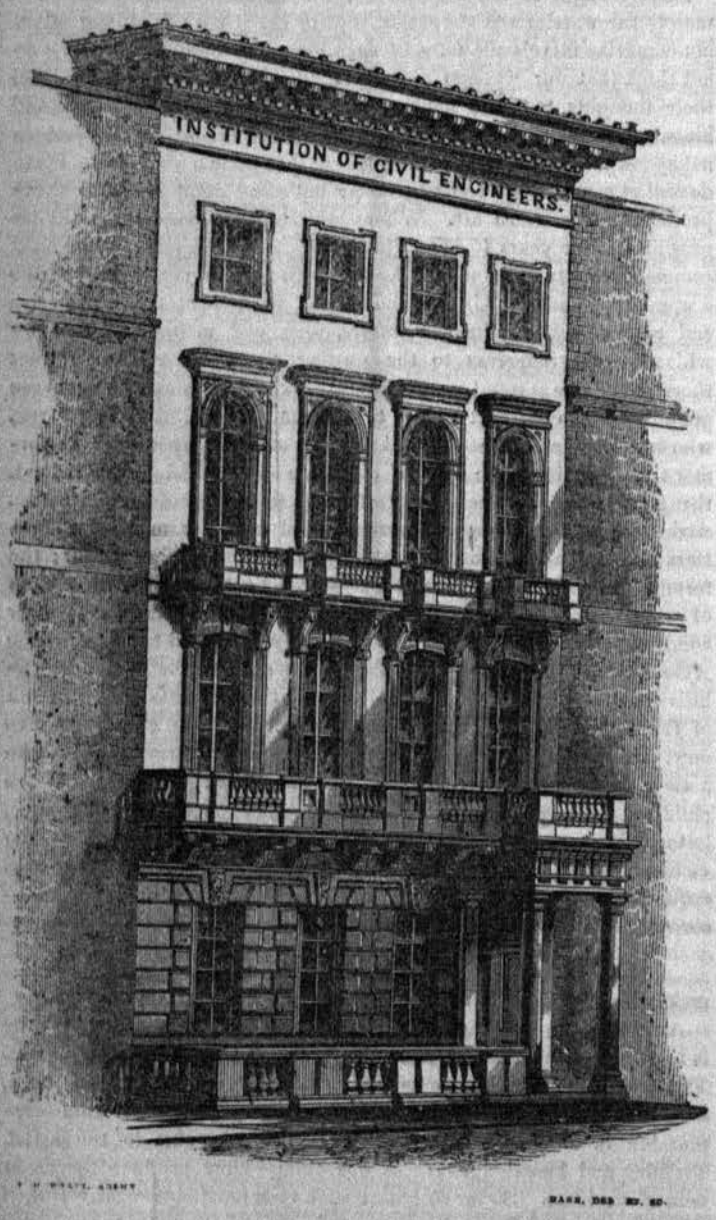
And then, the working man's sanatory association exclaim, "Why is there so much disease amongst us?" *We* know it—*they* do not. Young people's physical powers, if not (we would say terribly) used, will be terribly abused: thence our present pigmy generation—deplorable in all and every respect. But to revert to the artist. Training and knowledge are as one thing—they produce the *prosy man* of business. So far so good: such men must also exist. But, if the aspirations of the nation have to be raised above that, we cannot accomplish it but in the manner in which it has been before accomplished, cannot but be *so* accomplished, and *has* been *so* accomplished in Egypt, Asia Minor, Greece, Rome, Italy, Flanders. It is mere chimera to think that the mind can soar above, while the body is dwindling—crumbling down to the very soil, into the embraces of which it is hastening headlong. The thing cannot be done; we are

not mere spirits, mere minds—but, as Goethe has it, both are the same. It is well known, that several of the great artists of mediæval Italy were great fencers,—cheap *athletics*, indeed, accessible to all means. And then our young men must betake themselves again to the *staff* of the Grecian wise and good—to the knapsack worn by Cornelius, Overbeck, &c. Even a constitution and mind, somewhat damaged in Chancery-lane, may recover on the hills of Scotland or Wales, or amidst the luxuriant scenery and sunny skies of Southern Europe.

J. L——Y.

INSTITUTION OF CIVIL ENGINEERS.

[FAÇADE OF THE NEW BUILDING.]



We present our readers with a view of the new façade of the Institution of Civil Engineers, from the design of T. H. Wyatt, Esq.; as will be perceived, it is of the Italian style, and is faced with Caen stone, and forms an admirable specimen of street architecture. For the proportions of the openings of the doors and windows, Mr. Wyatt was compelled to be guided by those of the old brick elevation that was taken down. The frontage is 30 feet.

The building of the Institution has undergone, during the late recess, a complete metamorphosis; the theatre has been reconstructed and considerably enlarged, it is now 45 feet by 29 feet. The floor which was formerly nine feet above the ground line, is now reduced to that level; the seats of the president and council face the entrance, and those of the members are arranged in concentric curves, rising gradually up to the level of the entrance. The area of theatre is increased full one-third, giving accommodation to nearly one hundred persons more than the former room. The height to the ceiling is twenty-two feet. The evening lighting is partly through the inner skylight, by means of a gas ring, and by six gas burners provided with the means of conveying away the products of combustion. In the day-time, a skylight over the entrance, and three windows at the north-east end, afford ample light.

The ventilation is provided for by a shaft rising from the centre of the ceiling to a large cowl on the roof, and an ample supply of warm or cold air can be admitted, through apertures in the skirting, from Price's warm-water apparatus, according to the temperature of the theatre.

Above the theatre is a well-lighted room, for receiving the models and drawings, and affording accommodation for taking copies of them. The access to it is by a lateral staircase, from the ante-room, and also across the lead flat from the principal staircase.

The house department has likewise been considerably altered, and adapted to hold occasional conversazioni. The two rooms on the first floor, which form the libraries, have been thrown together, and by fixing a temporary staircase from the back window, a communication will be formed with the theatre, on the ground floor, for public occasions; the false floor for the raised seats will be removed, leaving a level floor the whole extent, and on the same level as the council-room and office, which will form, at those times, refreshment rooms, by this arrangement there will be a suite of rooms on the ground floor, 114 feet in length, and 29 feet wide.

There have been also alterations made in the other parts of the premises, and every attention made to the warming and ventilation, to render the building both convenient to the members, and suitable for the important occasions of the conversazioni.

The alterations have been conducted under the guidance and immediate direction of Mr. Manby, the indefatigable secretary, and the works executed by Mr. Grissel, the eminent builder, from the designs of Mr. T. H. Wyatt.

ON WATER AS FUEL.

This seemingly strange idea originated in an occasional remark of Sir Humphrey Davy—that on the problematic exhaustion of coal, men will have recourse to the hydrogen of water as a means of obtaining light and calefaction. As the gas used for lighting consists of hydrogen and a little carbon—it is only the latter which would have to be *added*, after the water had been decomposed into its elementary parts. M. Jobard, of Brussels, was the first who extracted from water a gas, of twice as great an illumining power as that obtained from coal. This gentleman produces hydrogen gas by the decomposition of vapour, passing through vertical retorts filled with coke, being in a state of white heat. And at the moment of the hydrogen being thus formed, it is mixed with a little carbonic acid gas, obtained by the distillation of oil, tar, or naphtha, or other coarse substance, hitherto useless in the gas manufactory. In the *Bulletin du Musée d'Industrie*, M. Jobard's method has been amply detailed. He says that at the expense of one pennyworth of oil, a light may be obtained during twenty hours, equalling that of ten tallow candles. Even conceding that M. Jobard's discovery has not quite attained the object of using water for light, fuel, &c.,—still, it has done something towards it.—These ideas lead us to a calculation of Prof. Faraday, that the elements of a single molecule of water contain 800,000 charges of an electric battery, consisting of eight troughs of two inches in height, and six inches in circumference. At the amount of these slumbering forces, the human mind is startled; because if we should ever be able to elicit and make them available, the power of the mightiest steam engines would dwindle to nothing—and thus, ends would be attained by the means of things seemingly trifling and worthless, which cannot now be accomplished by any sacrifice or expense.

J. L——Y.

STABILITY AND STRENGTH OF HUNGERFORD BRIDGE.

[Reply to the Objections raised in the "Civil Engineer and Architect's Journal" of December, 1846, to the Analytical Investigations and Dynamical Observations, contained in the Pamphlet entitled "Metropolitan Bridges," showing the Defects and Insufficiency of Hungerford Bridge, by Sir Howard Douglas.]

"In the pamphlet entitled 'Metropolitan Bridges,' &c., it is intimated that, at the tops of the piers of Hungerford Bridge, there exist horizontal forces, represented by $a - a'$, by which those piers are continually strained; and which, in consequence of the concussions produced by the vibrations of the Bridge, may ultimately destroy them.

Concerning these forces some explanations will presently be given; but as, in a well written paper which appears in the *Civil Engineer and Architect's Journal* for December, 1846, an attempt has been made to show that the danger which might arise from these forces is obviated by the friction rollers under the saddles to which the chains of the bridge are attached at the tops of the piers, and believing that there is ground for considering the effect of the saddles in diminishing the strain to be very small or nothing, we feel it incumbent on us, first, to say a few words on this subject.

It is much to be regretted that experiments on the friction of cylindrical rollers are as yet too few to allow any precise determination of its value to be founded on them, yet such experiments are not wanting; and from those of Coulomb principally may be obtained approximations which will suffice for the present purpose: it may be admitted, in fact, agreeably to many of the experiments made by that distinguished philosopher, that the friction of rollers varies inversely as their diameters, and directly as the pressures which they support. Now, suspending equal weights on opposite sides of a cylinder by means of a string passing over a pulley to which the cylinder served as an axle, and then applying on one side additional weights sufficient to overcome the friction, Coulomb found the values of that element for wooden cylinders of different kinds and sizes; reducing these, by the first part of the rule above mentioned, to cylinders four inches diameter, which is the size of the rollers under the saddles of Hungerford Bridge, the friction of wooden rollers is nearly one-hundredth part of the weight. This agrees with the experiments made by Mr. Babbage on wooden rollers, if as usual we estimate the power requisite to draw a body horizontally on a sledge to be one-quarter of the weight of the body. But all these experiments having been made with cylinders compressed by weights which are comparatively small, the above estimate is far less than it would be under the enormous pressure to which the rollers supporting the weight of a suspension-bridge chain are subject.

The experiments of Coulomb on iron axles turning between cheeks of copper give for the friction of metallic rollers a value bearing a much higher ratio to the pressures than that of wooden rollers: the diameter of his axles was 1·46 in. (English), and the friction, without grease, was one-sixth of the weight; this value, increased in the ratio of 1·46 to 4, gives, for the friction of iron four-inch rollers, one-fifteenth of the weight or pressure. It would seem, therefore, that the friction of such rollers, even in circumstances far more favourable to the freedom of their motion than those of the rollers under the saddles on the piers of Hungerford Bridge, cannot be estimated at less than the quantity last named. Now the pressure in the vertical direction, arising from the weight of the suspending chains on the tops of the piers on each side of the centre of Hungerford Bridge, being estimated at 850 tons, it must follow that the friction and inertia of the rollers are together equivalent to nearly 57 tons; or strains at the tops of the piers, to that amount, may take place before the saddles will move. What has been said must be considered as independent of the increase of resisting power in the rollers, arising from the probable alteration of their figures and the indentation of the planes on which they rest, in consequence of the great pressure to which they are subject, each of the twenty-five rollers* under the saddle bearing one-twenty-fifth of the weight on that saddle, or above 17 tons. The resistance arising from the force of cohesion may also, in time, become sensible under such pressure. The estimate of the friction of rollers on the pier of a suspension-bridge which, in the paper referred to, is derived from that of a railway carriage, is by no means admissible: as well might it be assumed that the body of a railway carriage, if moving on rollers four inches diameter, would have only half the friction which it has on its wheels. A railway carriage may be considered as moving on rollers whose diameters are ten or twelve times as great as those of the bridge rollers; and, if any comparison could be made between cases which are so much unlike, it should be inferred that the friction of the Bridge rollers, instead of being half that of a railway carriage, should be ten or twelve times as great.

By an oversight, it was stated in the pamphlet on 'Metropolitan Bridges &c.,' that the side chains of Hungerford Bridge have the same droop or deflexion as those in the centre; whereas, the side chains, being carried below the level of the road, the droop is greater, while the horizontal length or span is nearly equal to that of half the centre chain: the inference drawn from the difference between the parts of the chain, is, however, correct; the value of a' being still less than that of a. This is manifest from the approximative formula which is given in the pamphlet; since x^2 is small when compared with $3y^2$, and the whole numerator is divided by an increased value of $6x$. But if the weights suspended from the central and side chains be taken into consideration, the value of a' relatively to a will be much less than that which would result from merely substituting the augmented value of x in the formula above alluded to. For the weight of half the chains and roadway between the piers being estimated at 500 tons, while, between either of the piers and the abutment on the land side, the weight of the chains with the portion of roadway which they in part suspend, and in part support, is about 350 tons:* then, still, for simplicity, considering the curves as common catenaries, and using the correct formula for horizontal tension, viz., $a = \frac{s^2 - x^2}{2x}$ in which s, the length of the chain between the points of attachment (in this case, the length between the highest and lowest points of the curve,) may be taken to express the weight of the chain and loading between such points, it is evident that a' will be less than a, both on account of the smaller value of s and the greater value of x.

It is, therefore, very correct to say that there exists a force of considerable intensity, expressed by $a - a'$, which is constantly acting towards the river at the top of each pier, and which may ultimately be the cause of its destruction. And though it should be admitted that motion may take place in the saddles so as to produce some compensation to the excess of strain towards the middle of the river, yet the effect of such motion would be far from equalising the contrary strains. In the actual state of the Bridge, the horizontal tension of the side chains at each abutment is about eleven-twenty-fifths of the like tension of the centre chains: and a movement of the saddle to the extent of eighteen inches towards the river, while it would diminish the horizontal tension of the centre chains by about one-eight part of its value, would increase that of the side chains by one-hundredth part only; and this is the whole extent to which the compensation alluded to in the *Civil Engineer and Architect's Journal* for December (p. 365, col. 1.) would amount. It may be observed, that a strain which should cause a movement of a saddle towards the river to the extent of eighteen inches, must be accompanied by a descent of the lowest part of the centre chain as much as six feet vertically.

The effects of the strains at the pier heads may, obviously, with propriety, be determined by the parallelogram of forces as explained in the fifth page of the 'Reply' addressed to the Editor of the *Civil Engineer and Architect's Journal;* and of such resolution of forces an instance occurs in the description of a Jib-Crane, which appears in that journal for December, 1846, p. 367. It is not, however, to be supposed that a pier of brick or stone is overturned as if it were a vertical rod, capable of turning on a joint at its lower extremity only; this is an effect which can scarcely take place in such structures; but continual pressures and accidental strains at the head of a pier have tendencies to destroy the adhesion of the materials, and cause the pier to fall in ruins in consequence of a fracture taking place at the point where the fulcrum of the lever may be situated. The position of such point will depend upon the construction of the piers, and those of Hungerford Bridge are not solid in all their height, but each is perforated at a certain distance above the roadway by arched openings at right angles to one another, so that the top of the tower with the saddle is supported only on the four portions of the side-walls at the angles.

This construction renders the towers far less strong than they would have been if solid, and makes it very probable, that, in the event of undulations of the bridge producing a pressure even less than that value of $a - a'$ which has been above found, fractures will take place in those portions of the side

* These observations are all made with reference to an accurate plan, showing, in detail, the principle and construction, elevation, plan, and end view of the saddles on the tops of the piers; the girders, the coupling bolts, and suspension rods, the holding down girders, &c.; and very accurate observations have been made, by which it appears that there is very little, if any, shifting of the saddles, since the bridge was constructed, as stated at page 9.

* It must be observed, that this portion of the roadway, which is equal in length to half the distance between the piers in the river, is supported at both its extremities.

walls; while it is not impossible that, from unequal settlements in the bed of the river, combined with strains at the tops of the towers, the latter may be wholly overturned.*

From the estimate which has been made of the weight, (850 tons) on either of the pairs of saddles, and the horizontal pressure (57 tons) which may take place before the saddles will move, it may easily be computed by the parallelogram of forces, that in either of the two towers on one side of the centre of the bridge, the diagonal which represents the resultant of the forces would make towards the river, an angle of 3° 49′ nearly, with a vertical line passing through the centre of the saddle, and that the value of the resultant for one tower only, is 429 tons. The direction of this resultant, if produced, would fall within the base of the tower and therefore the latter may seem to have sufficient stability; but if, in the tower, a line be drawn from the top of a saddle to the foot of the opening, towards the river, at its middle point, that line will make an angle of 22° 45′ with the resultant just mentioned; therefore, multiplying the pressure in the direction of that resultant by the cosine of this angle we should have 395 tons for the pressure thrown obliquely on that side wall of the tower. Such a pressure, being but slightly counteracted by the tenacity of the walls on the other sides of the tower, would be sufficient to cause the wall to bulge towards the river, and would prostrate the fabric in ruins.

Under the enormous pressure which the saddles have to support, it may be presumed, that these have scarcely moved from their places since the construction of the bridge, having experienced only the slight agitations produced by the small number of foot passengers who have hitherto been on it at one time, and it may be readily admitted that, as yet, the strains on the pier-heads have produced no effects which appear to be detrimental to the stability of the bridge. But the case will be different should even such strains be long continued; and no one can, without dismay, contemplate the probable consequences of failure should such a bridge be frequently subject to the sudden rushes on it of bodies of people, and the rapid movement of numerous trucks and other carriages, laden with baggage, proceeding from the main terminus of the several stations and roads leading from Kent, Sussex, and the south-western counties, which it is proposed to establish opposite to Hungerford, and for which it is imagined this bridge may serve as a viaduct.

Melancholy instances of the fatal consequences attending the failure of these graceful but treacherous structures, are too frequently taking place. Mr. Trollope relates,† that while he was in the West of France, a suspension bridge over the river Dordogne gave way, at the time that a heavy van was conveying, to the place of their destination, criminals who had been condemned to the gallies, when the unhappy persons, being unable to disengage themselves, were all drowned; and an account of a still more lamentable occurrence is given in the *Civil Engineer and Architect's Journal*, for Jan. 1847, page 31. The suspension bridge recently completed at Jingurutchy near Jessore, and the iron-work for which had been obtained from England, gave way at a time when 5 or 600 persons had assembled on it to witness a poojah, and when three boats were passing under it; the sad accident was caused, as in the case of the Yarmouth catastrophe, by the whole crowd suddenly rushing to one side of the bridge; and it is reported that 100 persons were killed or drowned.

But a case which must be considered as one of the highest importance on account of the lesson which it offers with respect to the instability of suspension bridges when the great strains to which they, above all other bridges, are liable are not duly counteracted, is that of the *Pont des Invalides*, which was constructed across the Seine, between the years 1824 and 1826, and which immediately upon the centering being removed gave way, so as to render its entire removal a measure of necessity.

The span of the bridge was about 557 feet, and the deflexion of the chains, in the middle, nearly 33 feet. The dimensions of these were more than sufficient to enable them to resist the tension to which they would be subject; but the chains were supported on the tops of four Egyptian columns, (of which the two at each extremity of the bridge, were connected by iron braces,) and, descending abruptly from thence on the land side, they passed down a deep pit formed in masonry, to which, at the bottom, they were firmly attached.

If mere strength, unaccompanied by equilibrium, could have ensured stability, this bridge ought to have stood, a monument of elegance. But though here, as in Hungerford Bridge, there was an effort made, by permitting the chains to slide on the tops of the piers, to produce a compensation for an excess of pressure on the bridge, yet experience has shown that such compensation does not take place; and it is evident that, in consequence of the great friction, the horizontal pressure towards the river, is allowed to take effect at the tops of the supporting piers or columns; that pressure, ($a-a'$ above,) combined with the normal or vertical pressure of the chain, produced a resultant force which overturned the piers.*

It is remarkable that the project for the bridge was sanctioned by the approval of a commission constituted of engineers, in the department des Ponts et Chaussées, and that its construction was superintended by two engineers specially appointed for the purpose, as well as by the distinguished projector himself. It is painful also to reflect, that the failure of the bridge pressed so heavily on that talented individual as to cause his premature death.

The writer of the article in the *Civil Engineer and Architect's Journal*, endeavours to show, that the dangers which may be apprehended from vibrations, undulations, sudden additions of weight, and rushes of people, are rather imaginary than real, and treats this question as one purely statical, considering the bridge as a rigid, solid, inflexible structure. But it is clear that in all the preceding cases, as well as those of North Yarmouth and Broughton, the catastrophes that occurred, arose from the dynamical effects of oscillations and undulations; these the writer entirely rejects, on account of the difficulty of investigating and determining mathematically the effects of the forces, which ought to be taken into account, from the mutual action of the flexible bodies on each other. There is no doubt that it is extremely difficult to investigate these dynamical effects, and to assign precise values for them; but are we therefore to reject them altogether, in determining the strength which should be given over and above that which is required to sustain the statical pressure, and are we to make no allowance whatever for the additional strains which the dynamical effects produce? It might as well be said, that no considerations, with respect to the action of winds and waves of the sea, ought to be made in erecting Piers, Light-houses, &c., because we cannot estimate exactly their dynamical amounts."

The above is Sir Howard Douglas's rejoinder to the remarks made by us upon his former paper in this Journal. As might be expected of two disputants who set out, open to conviction, and determined that the discussion shall never digress to topics foreign to the question, there remains now but little difference of opinion between us. We think that he has made out a strong *primâ facie* case for the necessity of determining, by actual experiment, whether the "shifting saddles" be really efficient for their proposed object. At the same time, we still think the horizontal friction overrated: it is difficult to suppose that the rolling friction of wooden cylinders can be less than that of iron cylinders, and "the experiments of Coulomb on iron axles," included (we presume) the effect of *rubbing* friction, and therefore are not strictly analogous to the case before us.

The fact is we are contending in the dark. To make anything like an accurate estimate of the friction of the Hungerford Bridge saddles, we must not content ourselves with the confessedly inadequate experiments which have been hitherto made, but ought to make a direct experiment upon the Bridge itself. When the consequences of the failure of a Metropolitan Bridge are considered, it will not seem unreasonable to ask that this inexpensive investigation should be undertaken. Even supposing it ascertained that the saddles move with the greatest facility when the Bridge has its extreme load,† the mere fact of satisfying the public mind would be ample recompense for the trouble and cost incurred. Not only ought the Bridge to be secure, but every one ought to be satisfied that it is secure. As far as we know, Hungerford Bridge has never been in any way *proved* by heavily loading it.

By analogy, from what little is known of rolling friction from former experiments, it certainly still seems to us that the *statical* effect of the friction of the saddles would be small. But friction, like other forces, may be of the nature of impact. A crowd suddenly running from the side spans to the

* The piers rest upon the natural gravelly bed of the river, like those of Westminster bridge! surrounded by sheet piling driven, it is said, fifteen feet; an expedient which has not, however, prevented the subsidence and ruin of the two main piers of Westminster bridge. Though the towers of Hungerford bridge were erected in coffer-dams, there is no piling underneath.

† A Summer in Western France, vol. 2, p. 359.

* This description of M. Naviers' bridge is taken from an accurate plan in my possession, showing, in detail, the construction and dimensions of its several parts. The true causes of its destruction were, the inequality of the angles formed by the chains, with the vertical lines, at the towers, and the insufficiency of these at the abutments; both of which defects exist in considerable degrees in Hungerford bridge.

† If this were found not to be the case, many mechanical contrivances might be suggested for diminishing the horizontal strain on the piers.

centre span of the platform would produce a sudden or *impulsive* horizontal force on the top of the piers which could never be estimated from statical principles. There is, moreover, the apprehension of the rollers becoming, from long disuse, settled and fast in their place, by indentation, the accumulation of rust, or other foreign substances, &c.: from not being called into action under ordinary circumstances, they might be inoperative just at the time when they were wanted.* This point ought also to be examined experimentally.

We have confined our attention almost exclusively to the stability, and have said little of the strength, of the Bridge. The following seems a simple and satisfactory method of ascertaining the tension of the main chains at the points of suspension. If t be that tension, l the load borne by each half of the main chain, and θ the inclination to the vertical at the point of suspension, we know that

$$t.\cos\theta = l, \text{ or } t = l.\sec\theta,$$

whatever may be the form of the chain. In other words, we may ascertain the tension of the chain at its highest point, by multiplying half the total load by the secant of the angle at which the chain is inclined to the vertical at that point. The advantage of this method is, that it is independent of any assumption respecting the form of the catenary, and is strictly true, if we suppose what, in fact, is the case, that no part of the load is sustained by the platform itself resting on the piers. In answer to an application for the value of the angle in Hungerford Bridge, we were promised the particulars by Mr. Brunel, but subsequently found that he had been too much engaged to send them. Probably, the subject (the mere question of a few hundred lives) was too trivial to engage his attention.

There are many points in Sir Howard Douglas's paper on which remarks might be offered, but, for the sake of brevity, we refrain from making them; though, in one or two cases, our arguments seem to have been somewhat misunderstood. However, there can be no doubt that, if the traffic of Hungerford Bridge should appear likely, from a change of circumstances, to be hereafter greatly increased, the question will engage the attention of those who have more power than ourselves to demand information upon it. The inquiry which Sir Howard Douglas has personally undertaken (notwithstanding great obstacles), has, we believe, been most minute and laborious: such exertions can have no possible object but the public security and the advancement of engineering science, and ought, therefore, to be appreciated in proportion to their disinterestedness.

† The powerful effect of the accumulation of rust and concretions is frequently exhibited in a striking degree in the second or subsidiary safety-valves of steam boilers. These valves are never called into use except in unusual emergencies, and then, from long disuse, are often clogged and stick fast, notwithstanding the very great pressure exerted to open them.

HISTORY OF ENGINEERING.

By Sir J. Rennie, President of the Institution of Civil Engineers.

(*Continued from page 55.*)

Drainage.

In works of draining extensive districts of low marsh or fen lands, the Romans, with their usual energy and ability, effected much, and the Podike, Caer-dike, and the embankment of the Thames, amongst other works, are good examples. After they left the country, it relapsed into its former state of barbarism, and so remained for ages, until the art of drainage may be said to have been lost. Upon its revival the Dutch, from necessity, had become extremely skilful, and were celebrated throughout Europe at a remote period, almost before engineering commenced in Great Britain. On account of the proximity to England, and their experience in these kind of works, when it became a question of draining the extensive districts of low marshy land on the east coast of England bordering upon the Humber, the Witham, the Ancholme, the Welland, the Nene, and the Ouse, it was natural that recourse should be had to those who, from their skill and experience, had already acquired such reputation as the Dutch; accordingly we find, in the reign of Charles the First (when it was determined to drain the great level of the fens, afterwards called the Bedford Level, from the name of the Earls of Bedford,) Cornelius Vermuyden came over from Holland, and after draining the level of Hatfield Chase, adjoining the Trent, and acquiring considerable celebrity and influence, was knighted by the king. He planned great works in 1640, at the Bedford Level, for Francis Earl of Bedford, but the execution of Vermuyden's plans were prevented by the Civil War, and were afterwards carried into effect by William, the successor to Francis, Earl of Bedford, after much discussion and controversy, and were successful in draining the level to a certain extent. The plan in 1651 consisted in placing a sluice across the River Ouse, at Denver, about 15 miles from the sea at Lynn, where the Ouse enters the Great Wash, so as to exclude the tidal waters, leaving the channel of the River Ouse, above that sluice, for discharging the fresh waters only; these it was proposed to conduct from all parts of the land by small lateral drains or canals, carried to the river in as direct courses as practicable, having sluices at their junction with the river, to prevent the floods from entering them and covering the adjacent lands. He also cut a new channel, about 20 miles long, called the Bedford, or Hundred Foot River, for a part of the River Ouse, from the point where Denver Sluice was erected, to the old channel of the Ouse, at Earith, where another stanch or sluice was placed for preventing the tide from going beyond that point.

Vermuyden considered that by adopting this plan, and having only the fresh waters to contend with, he would get rid of that most powerful enemy to drainage, the tide; and then, having only to deal with the fresh water, he anticipated no difficulty in accomplishing the complete drainage of the land. For a time the plan answered tolerably well, and effected considerable improvement in the drainage; but he overlooked the important facts that the tidal waters formed the most important agent in keeping open the channels of the rivers, in preserving a good outfall for the drainage waters to the sea; that by excluding the tidal waters, the channel of the rivers would suffer, in proportion to the quantity of water which was thus abstracted from them, and that thus in time they would become incapable of effectually discharging the drainage waters; that the outfalls of the rivers would also suffer in the same proportion, and then the marsh-land districts, depending upon them for their drainage, would revert to their former inefficient state, and so it happened with the Bedford Level. The mouth of the channel of the River Ouse, which is the chief outfall for the drainage of the district where the Bedford Level is situated, being deprived of its accustomed and natural scouring power of tidal water, became so obstructed by shoals that the land waters could not pass off to the sea. In proportion as the drainage became defective in process of time, as it necessarily did under the system adopted, windmills were erected to work scoop-wheels, with a lift of 4 or 5 feet, for raising the water out of the lateral canals into the river. In 1713, Denver Sluice was undermined and blown up by the floods, and the tide recovered, to a certain extent, its ancient receptacles, and if proper measures had then been adopted, both the drainage and the navigation would have been restored to an efficient state; but the sluice was rebuilt after a few years on the old system, and the drainage and navigation became deteriorated as before. During the past century the drainage of the Bedford Level, as well as other districts, has been submitted to, and has occupied in succession the attention of the ablest engineers of the day; among whom may be mentioned the names of Perry, Elstobb, Grundy, Golborne, Armstrong, Kinderly, Smeaton, Jessop, Chapman, Page, Robert and William Mylne, Huddart, Rennie, Telford, Walker, G. and J. Rennie, Cubitt, Rendel, and others.

Amongst the most remarkable operations of this nature, may be mentioned the works upon the river Ouse, for the purpose of improving the drainage and navigation, which had become seriously affected by the accumulation of sands at its mouth, and the abstraction of the tidal waters above-mentioned. The principal defect existed immediately above the town of Lynn, where the river took an extraordinary bend almost at right angles to its general course, for a length of 5½ miles, forming almost a semicircle, the diameter of which was only 2¾ miles; independently, moreover, of this circuitous course by which so much fall or inclination of the current was lost, the channel was so irregular and disproportionate in width, and so much encumbered with shifting sands, that the tidal and fresh waters were unable to force their way through them; thus the drainage waters were penned up above, and being unable to get off, formed a tranquil pool, which during floods frequently broke the banks and inundated the surrounding country, the channel, moreover, being deprived of its natural scour, silted up in the same proportion. In order to obviate this great and growing evil, the ablest engineers of the day were consulted, and they unanimously concurred in the opinion, that the only sure means of providing a remedy was to cut off the bend in the Ouse, by making the shortest channel between its two extremities. This plan was first proposed by Bridgeman, in the year 1724, and was subsequently recommended by the various engineers of the day who succeeded him. In the year 1792, an Act was passed, after great opposition, empowering a certain body of Commissioners to carry into effect this cut, which was called the Eau Brink Cut, the expenses of which, estimated at about 80,000*l.*, were to be defrayed by a tax of 4d. per acre on the middle and south levels of the Bedford Level, comprising about 300,000 acres of land drained by the Ouse. This great work was to have been carried into effect by Robert Mylne and Sir Thomas Hyde Page; but they disagreed as to the proper form and dimensions of the cut, and referred the matter to Captain Huddart, who decided between them; so much money, however, had been spent in litigation, that the tax which was levied to pay for its execution was exhausted. In 1817, another Act of Parliament was obtained, empowering certain Commissioners to raise additional and increased funds from the lands which it was supposed would be benefitted by it, and the execution of the work with its branches was intrusted to the late Mr. Rennie, as the principal engineer. The Eau Brink Cut, which was executed according to the award of Huddart, and the works connected with it, were finished and opened on the 19th of July, 1821, and very beneficial effects, as had been anticipated, immediately followed; the extraordinary wet winter of 1821 which succeeded, proved its success beyond doubt, for soon after the cut was opened the low water line in the Ouse, immediately above it, fell five

feet, which necessarily produced a corresponding increase in the fall or inclination in the current, and thus gave it increased velocity and power to scour away and remove the obstacles in the bed of the river, and to discharge a greater quantity of water in the same time, as well as a longer period for discharging it, to the great benefit of the country drained by it. The tidal waters, moreover, being freed from the shifting sands and circuitous course of the old channel, and being confined in one mass in the new direct channel, acted with greater effect; finding their way upwards, and becoming united with the fresh waters in enlarging and deepening the channel above, they kept it open to its proper dimensions, and thus both the drainage and the navigation derived benefit from this great work. The improvement was carried still further, in adding one-third to the dimensions of the cut, particularly at the upper end; by this means an additional fall of about 2 feet 6 inches was obtained, making a total increase of about 7 feet 6 inches in the fall of the current at the upper end. The effect of these improvements has been to increase greatly the produce and value of upwards of 300,000 acres of land drained by the Ouse, which otherwise could not have been cultivated. The measure, like almost all other great improvements, encountered great opposition at the time. and in order to tranquilise the fears of some and satisfy the prejudices of others, various minor interior works were provided, such as locks and weirs, for penning up the water, most of which, but for existing prejudices, it would have been better to have dispensed with, and to have removed Denver sluice, raising the banks on the various rivers above, so as to have restored them to their natural state, and thus by admitting a greater quantity of tidal water, to have scoured out their channels, and thereby have enabled them to carry off the drainage waters more effectually.

A similar operation was executed by Telford and Rennie, on the river Nene, in 1829, at the Nene outfall, which commences about five miles below Wisbeach, and terminates at Skate's Corner, a length of nearly 5 miles, where it joins the great estuary of the Wash. The beneficial effects of this work have been very extraordinary; the low-water mark has been lowered 10 feet 6 inches, and a district of above 100,000 acres has been completely drained and brought into cultivation, which formerly for the greater part of the year was little better than a stagnant marsh; the navigation has been so much improved, that the tide rises 14 feet at Wisbeach, and vessels of 200 tons are now enabled to come up to that town, where previously the river was only navigable for small sloops; and at Sutton Bridge, 8 miles lower down, vessels of above 600 tons can arrive where formerly there was only water for vessels of 200 tons.

The river Nene having been thus improved, so as to enable it to carry off the tidal and fresh waters, an extensive plan for the interior drainage was designed and carried into effect by Telford, in 1830. It consisted of one main drain of proper dimensions, with two subsidiary drains of smaller capacity, extending above 20 miles, as far as Thorney, to bring down and discharge all the water from the low fen-land districts into the upper end of the new outfall, by means of a capacious new sluice with self-acting gates, which continues to discharge the water from the drains into the Nene, so long as the level of the water in the drain is higher than that of the river; but whenever the water in the river is higher, the sluice-gates close and prevent the river water from entering. This plan of Telford's resembled one previously proposed by Rennie for the same object, but which was upon a more extensive scale, and was accompanied by the important addition of catch-water drains.

In 1806, Rennie proposed and carried into effect a complete system of drainage, for an extensive district of fen-land, called the East, West, and Wildmore Fens, bordering upon the river Witham, into which they drained, about 10 miles above Boston. Rennie at once perceived the defects of the Witham as a means of drainage and navigation, and decided that until the river was improved by shortening its course and increasing the capacity of its channel, the complete drainage could not be effected. This plan he proposed, but the opposition was so strenuous that he was obliged to abandon it, and to carry his main drains into the river below the town of Boston: he divided the drains into two classes; one set he technically termed catch-water drains, which running along the base of the hills surrounding the low lands, intercepted all the high land waters, which, descending with great velocity, would soon have overwhelmed the low lands, in addition to the water falling upon them according to the extent of their surfaces. These high land waters were conducted by the catch-water drains into a main drain, which discharged the waters, by a self-acting sluice, into the Witham immediately below Boston; the low land waters thus freed from the high land waters, were conducted by separate drains into another main drain at Hobhole, about 5 miles lower down the Witham, where there was more fall. By this means both classes of waters were discharged without interfering with each other; means were also secured of discharging all the water by the lower drain at Hobhole, in case it should be found necessary, which ultimately happened, and it was made of additional capacity for that object. The district was thus completely drained, and from a stagnant marsh was converted into corn-fields.

The Witham being left to itself, became silted up in 1827, as had been foreseen by Rennie, and the neap tides scarcely flowed above 3 to 4 feet at Boston. The channel was then improved as recommended by him, and the river is now in such a state that vessels drawing 12 and 14 feet arrive at Boston, and the whole country drained by the Witham has been proportionably benefited.

He proposed a similar plan for the improvement of the Great Bedford Level in 1811, the cost of which he estimated at 1,188,189*l.*; but unfortunately for that district it has never yet been carried into effect, although it would have amply repaid the outlay. The origin of the above system, it is believed, is due to Rennie, although it is said by some that the Romans employed catch-water drains, and the Caer-dike is quoted as an example: it is, however, by no means clear whether it was not merely a navigable canal to connect the Nene and the Witham; at all events, the system, if ever it existed, had long been abandoned, and the revival, at least in modern times, is due to him. He also proposed the drainage of the Hatfield Chase and Ancholme districts, and Romney Marsh,* Holdernesse, and other districts upon similar principles, where drainage had been tried and had only partially succeeded.

After mature consideration and experience, it appears that the safest and most certain principles of drainage and navigation are:—The improvement of the channels and outfalls of the rivers, as far as may be practicable, for the free admission and discharge of the tidal and fresh waters; with interior drains, well laid out, of proper proportion and capacity for the low land, and catch-water drains for the high land waters; and according to circumstances, the drainage and navigation may be combined or kept separate.

Steam Drainage.—Where natural drainage could not be effected, or was only imperfectly applied, recourse was had to windmills and scoop wheels, as still used in Holland; these were always adopted until 1820, when Watt's steam engine was successfully applied by Rennie to work a large scoop-wheel, for draining Bottisham Fen, near Ely. Subsequently this valuable system has been applied and extended by Glynn, Field, and others, to the great improvement of fen-lands, by draining the water lower beneath the surface than could be done by windmills, which are now almost generally superseded by steam engines; the latter can be used when required, whereas the windmills can only be employed when there is wind; and it frequently happens that calms prevail during rainy weather, at the very time when the mills are most wanted.

Whilst carrying out the improvements of the outfalls and mouths of rivers, it often occurs that large tracts of sand and mud may be converted into fine arable land, fit for agricultural purposes, by accelerating the natural accumulation of warp, or alluvial matter, held in mechanical suspension by the water, and which, from the absence of proper measures, is otherwise carried away without producing any benefit. The works for this object and for improving the drainage and navigation, if properly conducted, consist generally in regulating and confining the channels of the rivers, through the sands below high-water mark, to one channel, for both the flood and ebb waters, and accelerating gradually the accumulation of alluvial deposit, by jetties and other light works adjacent to them; in proportion as the deposit accumulates, the works are raised until vegetation appears, which generally takes place about the level of high water of neap tides, and then the land is embanked from the sea. The system of warping or artificially soiling bad land where the levels will permit, has been practised for many years along the Trent, Ouse, and Humber, with considerable success. The operation consists in admitting, through sluices and canals made for the purpose, the water charged with alluvial matter in suspension, to the lands to be warped, which are surrounded with embankments, and after having deposited the alluvial matter the waters are conducted away again to the river; this process is repeated at intervals until the lands have been sufficiently warped, and thus lands which, in some cases, are situated several miles from the rivers, and were comparatively worth little, have become extremely valuable. If these operations be judiciously conducted, the outfalls of the rivers, and the harbours and drainage and navigation depending on them, may be greatly improved, and the land gained during the operation will, in many cases, amply repay the cost of draining it. In Holland, and other countries, there is a great field open: much depends upon the situation and other local circumstances; considerable judgment and skill is required in selecting the districts, and in properly applying the system, but its consequences are so important that it is well worthy of the attention of engineers. A scheme of this kind upon an extensive scale is about being carried into effect at the mouth of the Ouse and Nene, where above 30,000 acres of land will be gained, and great improvement will be effected in the drainage and navigation of the extensive districts drained by the Ouse and Nene. The same principle is applicable, in some cases, for converting shoals into effective breakwaters.

MACHINERY AND MANUFACTURES.

The improvement and extension of machinery and manufactures by new inventions and applications have been immense since the time of Smeaton. Previous to that period wood was almost exclusively used in the construction of machinery. Desaguliers, Leupold, Gravesande, and other writers, have given descriptions of the best specimens of mills and machinery in use a century ago, but they were very defective, both in proportion and construction, when compared with modern machinery for similar purposes. The introduction of cast iron by Smeaton, in 1754, was a great step in advance. He began by employing cast iron for the axis of one of his earliest windmills, in 1754; then in 1769, for the shaft of a water-wheel, and the main-wheel attached to it, for boring cannon at Carron; cast iron after-

* The difficulties here are peculiar, in consequence of the coast being surrounded with a broad belt of loose shingle, which renders it necessary to carry the drainage water through the sea banks by close tunnels, with valves at their outer extremities, so as to be forced open by the hydraulic pressure of the water. Dymchurch wall, or sea-bank, here is well worthy of remark: it was formed in the Dutch manner by stakes wattled together, and constantly required repair; it has since been faced with stone paving, at an inclination of about 6 to 1, which stands well, and resists effectually the heavy seas to which it is exposed.

wards was generally adopted for axes, but as some of them, which were improperly made, gave way, the application of cast iron in other machinery was in some measure retarded, until Watt applied his steam-engine to drive mills. The Albion Mills, constructed by Rennie, in 1784, and worked by Watt's steam-engine, may be considered as the first complete example of the employment of iron in every part of machinery, except for the teeth of some of the wheels, which were made of hard wood, for working into the iron teeth of other wheels; that example also showing the true form of teeth, with a fine pitch, and adequate depth and breadth and adjustment with each other, so as to work well together with the least friction, and the use of bevel gear, which is the perfection of modern millwork.

The great improvement effected in the design, proportion, and construction of millwork, together with the steam-engine, enabled machinery to be driven with greater velocity, increased action, and diminished friction, and thus greater effect was produced with the same amount of power.

We are indebted to our honorary member, Professor Willis, for his able investigation of the teeth of wheels, and to Whewell, Mosely, Jamieson, G. Rennie (for his new edition of Buchanan), and others, for their valuable treatises on mechanical and engineering subjects.

The Invention of the Spinning-Jenny, by Hargreaves, in 1767, and of the means of drawing out the fibres of cotton between successive pairs of revolving rollers in the water-twist spinning, by Arkwright, in 1769, followed by his system of machinery for carding and preparing fibres of cotton for spinning, in 1775, occasioned a complete revolution in the arts of manufacturing, and led to the establishment of the factory system, with its self-acting machinery. A somewhat similar system had, however, been introduced in the Silk Mills at Derby, nearly half a century before; but inasmuch as silk naturally consists of a series of fine threads, it is only necessary to twist or retwist them, in order to combine them together, which is a very simple operation, compared with forming the short detached fibres of cotton into a thread, without the aid of the hand to guide them; and to accomplish this by machinery was extremely difficult; it was, however, very ingeniously overcome by Hargreaves and Arkwright in different ways, both of which were combined together by Crompton in the mule in 1771. Arkwright's water-spinning was subsequently simplified into what is technically termed throstle-spinning, and together with his preparing machinery of 1775, was adopted for spinning worsted by Toplis, and for flax by Marshall. The carding machinery was also adopted, with suitable modifications, for preparing short wool, Hargreaves' spinning-jenny being used for spinning it into yarn for woollen cloth. The mule for a long while was only employed for cotton, but was adapted by Kelly in 1790, to be partly worked by power in aid of manual labour, and was soon after improved so as to spin extremely fine threads.

All these valuable inventions, together with a multiplicity of other ingenius contrivances connected with the factory system, were completed and brought into extensive use in the short period of 20 years. Machinery for printing calico was introduced by Peel, and perfected by others. Watt, in 1787, introduced chemical bleaching, which was afterwards carried to great perfection by Tennant. Cartwright, in 1787, invented cloth-weaving by power, although it was not brought into use until twenty years after, and, in 1790, he invented machinery for combing and preparing long wool, in preparation for being spun into worsted. Machinery for dressing woollen cloth by teazles was perfected, and Harmer invented machinery for shearing it in 1787. This has since been carried to greater perfection by Lewis. Bramah, in 1796, introduced the hydraulic press, which furnished the means of pressing cloth, books, papers, and other articles with a degree of force which could be accomplished by no other means, and its general adoption has been of great service. Self-acting machines for making button-shanks were invented by Heaton. Boulton's large manufactory at Soho contained many inventions besides those of Watt. He invented machinery for coining money by steam power in 1790, and erected a complete establishment at Soho, where, for a long time, he executed contracts for coining money for the British, and various foreign governments. His plan for stamping the pieces consisted in exhausting air, by pumps worked by a steam-engine, from vessels properly adapted for the purpose, and connected by valves with air cylinders, having pistons working the balance-beams of the coining-presses. By opening a valve, air is exhausted from within the cylinder, and the atmospheric pressure acting upon the piston, turns down the screw of the press which stamps the coin; by re-admitting air, the piston rises and with it the screw, thus producing an alternate rising and falling motion so as to strike from 50 to 60 pieces per minute; as the screw rises and falls, it works a feeding apparatus for supplying blank pieces, ready prepared for stamping, and as fast as one piece is stamped it is pushed off the die, and is replaced by another. The apparatus for cutting out the blank pieces is of a similar description; the whole is self-acting, and is a most beautiful and ingenious contrivance. These improvements were introduced into the Royal Mint, at Tower Hill, which was constructed in 1810, under the direction of Messrs. Boulton and Watt, who furnished the steam-engines and the coining machinery. The rolling machinery by Rennie, and the equalizing machinery of Barton, constructed by Maudslay, complete this magnificent establishment. At St. Petersburg, Copenhagen, Calcutta, and Bombay, Messrs. Boulton and Watt erected similar establishments, with rolling-mills by Rennie, at the two latter places.

The whole of the above ingenious and valuable inventions, except power-weaving, had been fully carried out and brought into successful practice before the end of the last century. The brilliant results which were obtained from these inventions excited, in an intense degree, the skill and ingenuity of a host of able mechanicians in the various departments above mentioned. The most minute operations were reduced to system by the use of machines, and the high profits derived from manufacturing by machinery, while the prices of the articles continued the same as those formerly produced by manual labour, occasioned a readiness before unknown to adopt all new machines, as well as to extend and improve them.

Water-Wheels.

The general introduction of self-acting machines induced the construction of more extensive mills of all kinds, and rendered necessary the use of more powerful and better regulated prime movers. Water-wheels were employed as the moving power at the early establishments of Cromford, Belper, Matlock, Bakewell, Lanark, Cattran, Deanstone, &c.; and when the governor was afterwards applied to water-wheels by Strutt, at Belper, the motion and power were regulated with a degree of uniformity almost equal to that of the steam-engine, and water was rendered as perfect a moving power as its nature admitted of. Rennie, it is believed, first applied the descending shuttle, by which the flow of water is regulated over its upper edge, so as to obtain the full benefit of the fall, instead of passing under the shuttle as formerly, whereby some of the fall is lost. He improved the construction of the wheel, increased the width and diminished the depth of the buckets, at the same time augmenting the velocity of the periphery from 3 feet to 5 feet per second. By these means nearly 75 per cent. of the power was realised. Strutt's improvements in water-wheels, executed by Hewes, consist in making them with slender iron arms and oblique tie-rods, with segments of teeth on the circumference of the wheel, turning pinions with nearly the same velocity as cranks of steam-engines, and rendering them almost equally applicable. In this department Donkin and Fairbairn have also taken a conspicuous part.

The Turbine, or a modification of the horizontal water-wheel, by Fourneyron, has latterly been introduced into this country from France, with, it is said, considerable success. The governor had been applied to windmills by Hooper, in 1789, and soon after Watt adapted it to his rotative steam engine, which was thereby rendered applicable for turning mills, and its superiority to water, and every other power then known, became manifest. The uniformity and certainty of the movement, its capability of extension to any amount, its applicability to any situation, rendered its adoption almost universal, and extended the sphere of manufacturing operations from the weaver's cottage and the banks of the lonely stream, to large populous towns, such as Manchester, Leeds, Macclesfield, and other places, wherever circumstances, independent of water, were favourable for their adoption.

The concentration of manufacturing operations, caused a number of small machines to be substituted for those formerly impelled by hand in workmen's cottages, and brought together in large buildings adapted for that purpose, and worked by one great moving power, and so combined with each other and the building, as to render a spinning-mill, with its water-wheel, or steam engine, and all its accessories, one vast and complicated machine. A new school for mechanics was thus formed, in which far greater power than had ever before been applied to machinery, was to be distributed amongst a number of delicate machines of the greatest variety of form and complexity, with some parts minute like clock-work, requiring every gradation of force to drive them, and corresponding strength in some for resisting the largest and others the smallest impulse. A new and extended field of inquiry and observation was thereby produced, which brought forward artists of every description to contribute their aid, as to one common stock of knowledge, for the advancement of the new system of manufacturing, as well for the invention of new machines and processes, as for the multiplication and improvement of those previously invented. The ingenious and valuable labours of the great mechanicians of the last century have been most ably continued by their successors, many of whom are, or have been, our contemporaries, and who with a greatly extended sphere of application, have advanced in the career of improvement with an almost unparalleled rapidity.

Many new machines have been invented, and most of those in daily use have been rendered self-acting or automatical, so as to require no further aid from man, than the mere act of presenting the materials to them to be manufactured, directing their progress through the machine, and disposing of them afterwards. The power loom, invented by Cartwright, in 1784, was afterwards improved by Austin, Miller, Horrocks, M'Adam, Lane, Bowman, and others, and its employment greatly extended.

Rope Machinery.—Machinery for making ropes and cordage was invented by Cartwright, Grimshaw, Chapman, and others, and subsequently carried to great perfection by Huddart, as exhibited in the establishment of Turner, Huddart, and Co., at Limehouse. This ingenious and valuable invention consisted in regulating and adapting the lengths of the different yarns, or threads composing the rope, so that each might bear an equal strain, which could not be done on the old system. To effect this, a series of bobbins, with the proper lengths of yarns wound upon them, were placed in a frame of a crescent form, and the yarns from these bobbins were conducted through holes in a vertical guiding plate, having those holes arranged in concentric circles; from thence the yarns passed through a vessel of liquid tar or pitch, and then through a single hole of the required gauge, on to a large reel mounted in an oblong frame, to which a rotatory motion about a horizontal axis, was communicated for twisting all the yarns together into a strand, and also a circular motion of the reel at

right angles to that of the frame, for winding the strand upon the reel, as fast as they were wound off the bobbins; a guide was attached which regulated the winding. The whole was worked by one of Watt's steam engines. By this beautifully-contrived piece of mechanism, the whole of the yarns were twisted into a strand of the required dimensions. The pitch and tar employed was used either cold or warm, and derived the appellation of warm or cold register cordage accordingly. The cables were formed by a larger machine, combining three of the above-described frames together, each having one of the strands to form the cable wound upon its reel; but the axes of the three frames, instead of being horizontal, as in the first case, were vertical, and all mounted in one large frame, which received a rotatory motion, about a vertical axis of its own, and carrying round the minor frames combined within it in order to twist the three strands together. The several strands were unwound from the reels, in the minor frames, as fast as the three were twisted together into the intended cable, which was drawn upwards between pairs of grooved rollers, disposed above the centre of the main frame, and the cable was conducted away by the same machinery and coiled up for use. Nothing could be more striking than the spectacle of one of these magnificent machines, resembling a great orrery in motion, pursuing its silent yet resistless course, producing the means of securing at anchor the gigantic vessel of war against the raging tempests of the ocean. This magnificent machinery, after returning a handsome reward to its ingenious inventor, and the enterprising capitalists who erected it, was bought by Government, and erected at the Royal Arsenal, Deptford. Chapman's rope machinery, and Curr's for making flat ropes, chiefly used for mines, as well as a new machine, lately introduced at Portsmouth from France, said to be the invention of Hubert, are worthy of notice.

Dyer's machines for making cards, for cotton and wool, and others for cutting nails; Wilkinson's, for making weavers' reeds; the self-acting mules of Eaton, Roberts, Smith, and others; those for weaving bobbin-net lace, by Heathcoat, Morley, and others; Holdsworth's, Dyer's, and other improved machines for preparing cotton rovings; Marshall's, P. Fairbairn's, and other machines for flax, are all ingenious and important inventions of self-acting machinery, well calculated to improve, expedite, and economise the manufacture of the various articles for which they were intended. Amongst the same class may be mentioned the curious inventions and improvements of Didot, Donkin, Fourdrinier, Dickinson, Crompton, Towgood, Ibotson, Kœnig, Nicholson, Tilloch, Congreve, Stanhope, Cowper, Applegath, Spottiswood, and others, for making and drying paper, and printing by steam; Oldham's various contrivances for printing bank-notes at the banks of England and Ireland; Lowry's, Maudslay's, Perkins's, and other machines for engraving on metal plates; Hollingdrake's method of casting copper under pressure, for engraving; Brunel's block machinery, executed by Maudslay, at Portsmouth, by which every operation is performed, from the sawing of the rough piece of wood until the perfect completion of the block for naval purposes; his saw-mills at Chatham and Woolwich; Bramah's planing machine at Woolwich; Wilkinson's machine for boring large cylinders, are splendid specimens of machinery; neither must we omit Watt's simple operation of making small leaden shot, by pouring melted lead through holes in a cullender at the top of a lofty tower, when they assume a spherical form in cooling, as they fall through the air, and finally into cold water below. Leaden bullets are compressed into a spherical form with great solidity by self-acting machines by Napier. The manufacture of crown and plate glass has been improved, and promises great extension; in this latter branch, Green, Pellatt, Chance, and others, are making great progress. The universal and widely extended application of machinery to every manufacturing operation rendered a corresponding activity and means of supplying the increased demand for it absolutely necessary; and additional means of making machines have been invented. Self-acting turning lathes, with slide rests, planing machines for metals, also for screwing bolts and nuts, were introduced by Fox; mortising machines, similar to those of Brunel, were adapted by Sharp and Roberts for metals, and shaping machines by Penn; these have been improved by Whitworth, Nasmyth, and others, by whom also new ones have been invented. The former has introduced an ingenious adaptation of machinery for sweeping roads and streets, and which, from its efficiency, is coming into general use; and to the latter we are indebted for the steam hammer and steam pile-driving machine, which serve materially to economise and facilitate these operations. Rennie, as far back as 1801, had applied steam for driving the piles of the coffer-dam for the London Docks; it has since been applied at Sunderland for a similar purpose, and he proposed it for working the cranes there as well as at the West India Docks; but it was not adopted. Otis' American machines for excavation have been tried, but are not as yet much employed. The invention and application of these various new and ingenious contrivances, furnished the means of executing machinery with a degree of economy and accuracy which without them could never have been attempted.

With the advancement of machinery, the art of founding in iron, which commenced at Carron, soon became an indispensable part of machine making. In this department Boulton and Watt took the lead, in consequence of the demands for their steam engine, and made great improvements in it, which were afterwards followed by Maudslay, and by others. The working in metals towards the commencement of this century thus became so much facilitated, that it was generally adopted, instead of wood, for the framing and moving parts of machinery; and castings in iron, of excellent quality, could be obtained in any number exactly like each other, so as to be fitted together with great facility. In the progress of modern improvements, wrought or forged iron came into more general use, and was substituted for cast iron in many cases, such as for railways, suspension bridges, tie beams, and roofs for buildings; various parts of steam engines, mill-work, and machines of different kinds, and in some instances steel has been adopted. As the improvement in machinery for manufacturing advanced, so did the arrangement, convenience, economy, and construction of the buildings in which it was contained; fire-proof arching for floors, with cast iron beams, wrought iron ties, cast iron columns, and wrought and cast iron framing for roofs, window frames, and every other part where the introduction of metal was practicable; in these improvements, Strutt, Rennie, and others, took a leading part. Apparatus for warming buildings by heated air was adopted by Strutt and Sylvester; and by steam, which had been employed by Smeaton, for drying gunpowder, was generally introduced by Snodgrass in 1798, and improved by Houldsworth and Creighton. This system has been more recently succeeded by that of heating the air by contact with pipes or vessels, in which a circulation is kept up, as practised by Price, Manby, Perkins, Haden, and others. These and many other improvements have been introduced, and combined in the most scientific manner in the great cotton-mills of Messrs. Phillips and Lee, M'Connell and Kennedy, Houldsworth, Birley, and numerous others, at Manchester; Messrs. Horrocks' at Preston, Strutt's at Belper, the flax-mills of Marshall, and the woollen-mills of Messrs. Gott, at Leeds, and of Wilkins near Bath, the silk-mills of Grote at Yarmouth, the lace-manufactories of Heathcoat at Tiverton, Boden and Morley at Derby, and Fisher at Nottingham, Cartwright and Warner's steam power stocking-weaving manufactory at Loughborough, and many other magnificent establishments all over the kingdom. The workshops of Fox, Nasmyth, Sharpe, Roberts, Whitworth, and others, for making tools; the steam engine and machine manufactories of Boulton and Watt, Fawcett, Bury, the Butterly Company, Stephenson, Hawthorn, Donkin, Hall, Fairbairn, Hick, Napier, Miller and Ravenhill, Maudslay and Field, Penn, Rennie, Seaward, &c., are a few of the vast establishments which abound, and which fill us with astonishment at the immense productive powers of this country; we are at a loss which to admire most, the genius and skill which has designed them, the energy and talent which directs them, or the capital which has brought them into operation. For accounts of many of the numerous branches of the immense manufacturing industry of Great Britain, we are indebted to Farey's articles in the Cyclopædia of Rees, the Encyclopædia of Brewster, and the Supplement to the Encyclopædia Britannica, also to those of Babbage and Barlow in the Encyclopædia Metropolitana, and likewise to Dr. Ure.

The improvement and extension of manufactures required a constant, active, and steady communication between the several districts where they were carried on, and soon produced a corresponding improvement in the roads, railways, canals, rivers, and ports. The cost of every article was reduced to the greatest nicety, and economy was carried to the minutest degree; being so intimately connected together, the extension of the one kept pace with the other. The same may be said of the arts of mining and metallurgy, by which coals for fuel and metals for manufactures are furnished to the different establishments.

WATERWORKS.

In the supply of that important necessary of life—water, which was so much studied by the ancients, but so greatly neglected in the middle ages, great progress has been made in modern times. Spring water was formerly conveyed to public reservoirs in the City of London, by leaden pipes from various springs in the vicinity: viz., from Tyburn in 1236, from Highbury in 1438, from Hackney in 1535, from Hampstead in 1543, and from Hoxton in 1546. For these useful works, the citizens were indebted to the munificence of several lord mayors and other individuals, but those of Hampstead and Highgate are the only ones now remaining. The open watercourse or conduit from Dartmoor, 24 miles long, for supplying Plymouth with water, commenced by Sir Francis Drake, in the reign of Elizabeth, and the New River, for the supply of London, 39 miles long, 28 feet wide, and 4 feet deep, falling 3 inches in a mile, by Sir Hugh Middleton, in 1613, are considerable works of the kind, and were planned and executed at the cost of those distinguished individuals. Middleton was, in fact, ruined by it, and adopted the profession of an engineer and surveyor to obtain a livelihood.

London Bridge Waterworks were commenced by Morice, in 1582, with water-wheels turned by the flood and ebb current of the Thames, passing through the purposely-contracted arches of Old London Bridge, and working pumps for the supply of water to the metropolis; it was the earliest example of public water service by pumps and mechanical power, which enabled water to be distributed in pipes to dwelling-houses. Previously, water had only been supplied to public cisterns, from whence it was conveyed, at great expense and inconvenience, in buckets and water-carts. In addition to the London Bridge and New River, several minor establishments of the same kind were afterwards erected on the banks of the Thames, to supply separate districts in their immediate vicinity. Some were worked by water-wheels on the sewers which discharged themselves into the Thames; others, by horses; and one by a wind-mill. That at Broken Wharf in 1594, at Shadwell and York Buildings, worked by horses, and at Chelsea by water-wheels, may be mentioned. Early in last century, when the old cisterns had nearly disappeared, and water was supplied to the dwellings, a great improvement took place, by the applica-

tion of the steam engine (which had then begun to develope its extraordinary powers) to the York Buildings Waterworks by Savery, in 1710, and afterwards by Newcomen in 1730. Newcomen's engines were subsequently applied at Chelsea, Shadwell, Stratford, London Bridge, and the New River Waterworks. As soon as Watt had brought his improvements into operation for pumping water, his engines were applied at each of the above waterworks by degrees, in addition to the old engines, thus a comparison between them could easily be made; and soon showed the superiority of Watt's engine in every respect. They were thus applied at Shadwell and Chelsea Waterworks in 1778, at London Bridge and Lambeth soon after, and at the York Buildings in 1804. The usual mode for the old engines was to pump the water into a cistern, at the top of a high tower, and from thence it descended through pipes, to the districts and buildings where it was required; the engine was thus always kept to its full load, whether necessary or not, and a waste of power ensued. Air-vessels were afterwards added to the pumps at Chelsea, and subsequently became general; the air in the vessels being compressed, acted by expansion and contraction on the water, so as to force it with regularity through the pipes, without going up to the cistern. Smeaton, who had constructed water-wheels for pumping at Stratford in 1763, and at London Bridge in 1767, where towers were employed, afterwards became the principal proprietor of the Deptford Waterworks, and in 1773 constructed a water-wheel for pumping water from the Ravensbourne without a tower. The machine is still in existence, although steam engines have been subsequently applied. About 1810, Boulton and Watt's improved pumping-engines, constructed wholly of metal, and erected in handsome substantial buildings of brick and stone, with large air-vessels for pumping direct into the pipes, became generally adopted at all the London waterworks; cast iron pipes were substituted for the old ones of wood. The new engines being more powerful, and the cast iron pipes stronger, enabled water to be distributed to cisterns on the tops of dwelling-houses, hence denominated the high service. Stone pipes were tried at the Grand Junction Waterworks, but failed, and iron pipes were substituted. Filtering reservoirs upon a large scale were constructed at Chelsea by Simpson in 1830, and subsequently at other places, with complete success, and are now universally employed. The water is now generally taken from the Thames above the town, where it is least adulterated. The old waterworks lower down the river, viz., York Buildings, London Bridge, the Borough, and Shadwell, have been abandoned, and new places chosen at Hammersmith and Brentford, higher up the river, and at Old Ford upon the river Lea; the river water is received into capacious settling, or filtering reservoirs, and distributed by steam engines to the respective districts. Latterly, powerful condensing steam engines, very similar to Watt's, but worked by high-pressure steam with great expansive action, on the system introduced by Woolf, in Cornwall, for deep mines, were introduced by Wickstead, in 1840, at the East London Waterworks,[1] and have since been adopted by other Companies with advantage in saving fuel. The double cylinder high-pressure condensing engine, with great expansive action, on the system of Hornblower, have also been introduced by Woolf, Hall, and Rennie, and applied to work mills with success. Waterworks, similar to those in the metropolis, have been erected at Edinburgh, Glasgow, Dublin, Manchester, Liverpool, and all the principal towns in the kingdom. At Glasgow, one of the last engineering efforts of Watt was to suggest the idea of laying a pipe under the Clyde, to bring water to the city from the opposite side of the river; this was to have been effected by making the pipe with flexible ball and socket joints, uniting the whole together in one piece, and closing it at each end, floating it to its position, and sinking it.[2] Rennie effected a similar operation at York Buildings in 1810. The increased means for the supply of water, and the economy and punctuality with which it is distributed, has occasioned a greater consumption, and induced a degree of cleanliness throughout all classes, which has tended to augment the comfort and health of the community. Still the system is capable of improvement: larger reservoirs and more copious supplies are necessary.

Artesian Wells, which appear to have been known to the ancients, and have been common in France and Italy, were introduced into this country about the year 1790, it is said, by Vulliamy, near London. The system consists in boring holes or wells through the superincumbent strata, impervious to water, until they reach the porous strata where water abounds, the pressure then acting according to the level from whence the water is derived, forces it upwards through the holes, frequently to some height above the surface; these have since been multiplied all over the kingdom during the present century, and latterly in Trafalgar-square,[3] for supplying the first public fountains which have been erected in the metropolis. These fountains, though upon a small scale, are a beginning; and it may be hoped that this example will be generally followed for the ornament of this great city; which, although perhaps the best supplied with water in the world, has not been adorned with fountains, which are so general, and are constructed upon such a grand scale at Paris,[4] Rome, and almost all the other great cities in Europe, adding so much to their magnificence and salubrity. In carrying out the improvements above mentioned for the supply of water, the names of Smeaton, Watt, Mynle, Rennie, Telford, Simpson, Bateman, Anderson, Clark, Wickstead, Walker, Martin, and others, must not be forgotten; and we shall no doubt witness efforts upon a still greater scale in future. Projects for bringing a large supply from the Thames, above Windsor, by Rennie; also from the Colne and Wandle, and Darenth, and elsewhere, by Telford, Rennie, and others, have long been in agitation, and sooner or later may be effected with advantage to the metropolis.

[1] See C. E. and A. Journal, Vol. 3, 1840, p. 65. [2] Vol. 2, 1839, p. 451. [3] & [4] Vol. 8, 1845, p. 133.

Sewage.

Connected with the supply of water for domestic purposes, we must not omit the important subject of sewage, or surface drainage, upon the due operation of which the health of the community so much depends. Sewers appear to have attracted notice at an early period, and during the reign of Henry VIII. commissioners were appointed with extensive powers to levy rates for, and to see them properly carried into effect; but until under ground or covered sewers were adopted, all the surface water from the adjacent hills and country, as well as the refuse from the buildings, was discharged into open ditches and street gutters, which, passing through the centre of the town, accumulated, and occasionally remaining stagnant for a considerable period, produced a degree of effluvia and malaria extremely prejudicial to the health of the inhabitants. This was remedied to a certain extent, by covering over the open drains; but the bottom of these were not low enough, and the want of surface drains continued. By degrees, covered sewers, of enlarged capacity, entirely of brickwork, were introduced; the importance of the subject then became duly appreciated and studied; sewers were laid out upon a general and enlarged system; main, subsidiary, and surface drains, and cesspools of a proper form, construction, and capacity, adapted to each other, and to the several districts they were to drain, were designed, and, in many cases, carried into effect. The subject is still under consideration, and improvements are being daily effected, although much still remains to be done in the form, capacity, inclination, distribution, and arrangement of sewers, not only in the metropolis,* but in almost all the principal towns of the kingdom, before the system can be said to be complete. The removal of Old London Bridge, by which a fall of about 5 feet at low water has been gained, has been of immense advantage in improving the drainage of the metropolis; and it only remains for this great improvement to be carried out further, by removing the shoals and regulating the high and low water channel of the river, by dredging and other means, but to be cautious in contracting the width. It is greatly to be desired that this important work should be speedily carried into effect, upon a general scientific system, which, if properly done, would confer the greatest benefits upon the extensive and populous districts, draining into and bordering upon the Thames, as well as the navigation of this noble river, upon the proper maintenance of which the immense commerce, health, and prosperity of this great metropolis, and its adjoining populous vicinity, depends. In the improvements of sewerage, Cubitt, Barry, Donaldson, Gwilt, Hardwick, Nash, Smirke, Soane, Walker, Rennie, Roe, and others, have been conspicuous.

Gas.

It is difficult to point out with accuracy the date of the invention and introduction of that invaluable substitute for daylight, or artificial lighting, carburetted hydrogen gas. It is generally believed, however, that it may be attributed to William Murdoch, soon after he succeeded to the management of Boulton and Watt's steam engine works at Soho, although the inflammable properties of that gas had been long known. Murdoch's first apparatus was erected at Soho, and he successfully illuminated that establishment with it in 1802, in celebration of the Peace of Amiens; he afterwards constructed similar apparatus on a large scale at Leeds, for lighting Messrs. Gotts' woollen manufactory, and for Messrs. Philips and Lee, at Manchester, and published an account of it in the "Philosophical Transactions" for 1808. Clegg, who was brought up at Soho, also published an account of it in the "Transactions of the Society of Arts" in the same year. It was subsequently, by degrees, introduced into several large manufactories in Lancashire; Winsor afterwards exhibited it in Pall Mall, where it excited a good deal of attention; but the general application of gas for lighting towns was for some time retarded, in consequence of the failure of several attempts by inexperienced persons, which prejudiced the public against it, so that it was not until the year 1813, that apparatus of efficient and proper construction was made, and erected in London by Clegg, Farey, and Manby, upon the same principle as originally introduced by Murdoch. The employment of gas for lighting towns and buildings has now become almost universal here as well as on the Continent. It is manufactured by distillation from coal in cast iron or clay retorts, and collected in immense gasometers, some of them 100 feet diameter, 44 feet deep, and capable of containing 390,000 cubic feet; thence it is distributed through cast and wrought iron pipes, under properly regulated pressure, many miles from the place where it is made; and self-acting meters, invented by Clegg, are applied at each building and district, in order to ascertain the amount consumed. It is purified by lime, sulphuric acid, &c., and its brilliancy is augmented by naphtha. In the various contrivances and details of the apparatus, and in the processes for manufacturing it, as well as in the economy of management, many improvements have been made by Clegg, Lowe, Manby, Philips, Croll, Crosly, Hedley, Edge, and others. When we compare the present mode of lighting towns and public buildings with gas, with the old system of oil lighting thirty years ago (even allowing that to have been a vast improvement upon the custom of our ancestors), we are astonished at the amelioration, and can scarcely comprehend how we could have gone on so

* There are nearly 500 miles of covered sewers in the metropolis.

long without it. Thus we find that the general adoption of every great improvement creates a refinement and fastidiousness of taste which stimulates others, so that we can no longer tolerate those imperfections which in a less advanced state of civilisation were passed over unnoticed. The introduction of oil gas by John Taylor, and by Taylor and Martineau; Gordon's system of condensing into close vessels for rendering it portable; and resin gas by Daniell, must not be forgotten, on account of the superior light produced from those substances, although it has been superseded by the more economical coal gas, and when naphthalized on Lowe's plan, its light appears so pure as scarcely to be suscepticle of improvement. Gas for lighting on an extensive scale was introduced into France by Manby in 1820, and has since become general on the Continent. The use of gas-light in private dwelling-houses is gradually extending, and as the objections of smoke, bad smell, and risk of explosion, are fast disappearing before the exertions of the modern improvers, it will become more general; the ingenious contrivance of Faraday, conveying away by pipes all the products of combustion, is worthy of notice.[1] Clark and M'Neil's, and other burners, which insure more perfect combustion, are decided improvements.

The employment of gas for Lighthouses promises important results; for there, almost any reasonable degree of cost and trouble in perfecting the light, so that it may be rendered more distinctly visible at greater distances at sea, will be amply repaid; in this class may be mentioned with praise the oxy-hydrogen light of Drummond, and the Bude light by Gurney. Latterly, the catoptric and dioptric system of Fresnel, which consists in an ingenious and scientific construction of the lenses, and an adaptation of the compound argand burners to suit them, has been introduced into several of our light-houses with advantage, but further experience is necessary to decide which is the best,—the system of Fresnel above mentioned, or the old argand system with the parabolic polished silver reflectors; both plans have been well executed by Wilkins and by Deville.

In the construction of Lighthouses since Smeaton, Messrs. Stevenson's and Walker have done much, and recently Gordon's cast-iron Light-houses[2] appear, for certain situations, to merit attention.

ROADS.

In proportion as the wealth and commerce of the country increased in the latter half of the last century, so it became absolutely necessary to improve the communication by roads and wheel-carriages, between all the different towns and districts of the empire, for supplying them with provisions, fuel, and the necessaries and luxuries of life, with greater facility and economy, as well as for expediting commercial and general intercourse, in fact, the one followed as the necessary consequence of the other, and the public seeing and feeling the beneficial effects of what had been effected, and convinced of the practicability and advantage of proceeding further in the cause of improvement, would not rest satisfied until those improvements were made; accordingly, the improvements of roads attracted general attention. Originally, roads were mere footpaths, or horse tracks, across the country, in the most convenient and shortest direction between the desired places, but wholly unadapted for wheeled carriages; by degrees they became practicable for the rude carriages of the times, and were maintained in a very defective state by local taxes on the counties or parishes in which they were situated; nevertheless, nothing in the way of effectual improvement was attempted, until turnpike trusts were established by law, for raising or levying tolls or taxes from persons travelling upon the roads. Several Acts of Parliament for these trusts were passed previous to 1765, but in the early part of the reign of George III. many more were passed, notwithstanding violent opposition was made to the tolls. They subsequently became general, and penalties were recoverable at common law, against the trustees, for not keeping the roads in proper repair; a long period, however, elapsed before any good system of road-making was established. The old old crooked horse tracks were generally followed, with a few deviations to render them easy; the deep ruts were filled with any materials which could be obtained nearest at hand, and were thrown upon them in irregular masses, and roughly spread to make them passable: the best of these roads would in our time be declared intolerable. Road-making as a profession was unknown, and scarcely dreamt of, and the parties employed to make and keep the roads in repair were ignorant and incompetent to do their duties; but inasmuch as travelling was uncommon, and the funds at the command of the trustees were scanty, we cannot be much surprised at it, as they could not command higher talent. Engineers, except in cases of great difficulty, such as making a bridge over a deep and rapid river, cutting through a hill, or embanking across a valley, where more than ordinary skill was required, considered road-making beneath their consideration, and it was even thought singular, that Smeaton should have condescended to make a road across the valley of the Trent, between Markham and Newark, in 1768. The great activity and prosperity, however, which resulted from the modern manufacturing system, convinced people of the value of time, and that easier and more rapid means of communication than the old roads permitted were required; hence, the acclivities were partially reduced by cutting down the hills and raising the intervening valleys; improved bridges were built with easier ascents, and in some cases cuts were made to shorten the distance; still, however, the general line of the old road was preserved. The roads were certainly improved by these means, but still there was no general system; they were parcelled out into small districts under separate trustees, without any common concert or harmony in working together, and but little effectual progress was made. The importance of forming good roads was but imperfectly understood, the legislation connected with it was equally short-sighted, and many of the improvements in cutting down hills and levelling valleys were frequently repeated, from want of proper skill and foresight at first. The rebellions in Scotland, in 1715 and 1745, induced the government of that day to turn their attention to the subject, and several roads were constructed by military engineers for military purposes.

Telford, previous to his being employed to construct the Caledonian Canal, had turned his attention to road-making, and was appointed by the government to lay out new lines of road, both for the purpose of employing the then poor and thinly scattered population of the Highlands, as well as to improve the districts by more general intercourse with the rest of the kingdom; he evinced a skill and knowledge which had not hitherto been bestowed on this important subject, but which was afterwards developed upon a greater scale in Ireland, and lastly in England, in his great works, the Holyhead, Liverpool, and Great North Roads, formed in consequence of the increased communication with Ireland after the Union, and which were excellent models for roads throughout the kingdom. Telford set out the roads according to the wants of the district through which they were made, as well as with a view to more distant communication, and the acclivities were so laid out, that horses could work with the greatest effect for drawing carriages at rapid rates. The road was formed by a substratum of large stones, with sufficient interstices between them for drainage; the materials laid on this foundation were hard and angular, broken into small pieces, decreasing in size towards the top, until they formed a fine hard surface, whereon the carriage-wheels could run with as little resistance as possible. The transverse section of the road had no greater convexity or rise, than was sufficient to cause the water to run steadily into the side-drainage channels; by this means, the carriages not being inclined laterally, the weight was more equally divided on the wheels, whereby they moved more easily and with the least wear and tear of the roads. The surface of the road was always kept even and clean, by the addition of proper fresh materials where necessary, and distributed equally in thin layers immediately after rain, in order that the new materials might bind and incorporate properly with the old. Telford's system was afterwards extended by his assistant, Macneill, and is fully described by our late honorary member, Sir Henry Parnell, afterwards Lord Congleton, who, by his perseverance and support of Telford, mainly contributed to its extension and success. About the year 1816, M'Adam introduced his system, and brought it into general use in the vicinity of Bristol. It resembled in some respects that of Telford, but differing from it by making no foundation in the first instance; it consisted in simply laying a stratum of flints, or other hard materials, 10 or 11 inches thick, broken equally into small pieces about two inches diameter, and spread equally over the intended road; this soon became so consolidated together by carriages passing over it, that they could travel with great facility and expedition. The section and the mode of applying fresh materials and keeping it clean, resembled that of Telford. M'Adam, professing to be a road-maker only, devoted his whole time and attention to the propagation of his system, which was greatly superior to the old, and became very generally adopted. Its introduction and extension was in a great degree due to our honorary member, the Earl of Lonsdale, who is ever alive to improvement; and to his lordship's exertions we are indebted for the present system of metropolitan roads, which has proved of great advantage to the public.

Carriages.—The great improvement in roads, which was accompanied by a corresponding improvement in the carriages and breed of horses, produced an extent of travelling commensurate with the increased facilities afforded. Coaches were first introduced into England in 1580, about the time of Elizabeth. Public, or hackney-coaches, were only established in London in 1625; and stage or public travelling coaches, not until a much later period: in fact, there were few roads upon which they could pass; and for fear of being robbed by highwaymen, or of being overturned or stuck fast in the mire, and other accidents of the road, they seldom or ever travelled during the night. In 1666 (the year of the Fire of London), a coach was established, which travelled between London and Oxford in two days; and another, called the Flying Coach, afterwards started to perform the journey in thirteen successive hours, or at the rate of 4 miles an hour, but only ran during the summer months. The journey between London and Edinburgh by stage coach, which was begun in 1712, took thirteen days to perform the journey: in fact, so great was the difficulty and danger of travelling, that, before setting out on a long journey, people made their wills, as if they never expected to reach their homes again. After the roads had become sufficiently improved, mail-coaches, upon an improved construction, to carry passengers and letters, were first introduced by Palmer in 1784, and the journey between London and Edinburgh was reduced to three days and nights by this conveyance. At the first appearance of this extrordinary novelty, the inhabitants of the rural districts crowded the roadside to see the royal vehicle, with its gaily apparelled horses and scarlet liveried coachmen and guards, galloping by at the accelerated speed of 7 or 8 miles an hour; but, when it was increased to 10 and 11 miles an hour, by further improvements in the roads, carriages, and axles, by Vidler, Collinge, and others, ameliorating the breed of horses, and shortening the stages, and the distance between London and Edinburgh was performed in 42 hours, it was considered that this could not be exceeded—and so far it was true; for animal strength and endur-

[1] See C. E. & A. Journal, Vol. 6, 1843, p. 196. [2] Vol. 4, 1841, p. 333.

ance had reached its utmost limits, and, if any improvement was to be obtained, it was requisite to obtain it from a different source. In the race of improvement, the stage coaches were not behind the mails; and we have only to mention the Brighton, Oxford, Cambridge, Southampton, Shrewsbury, and other coaches, to prove that the system was carried to the highest degree of perfection of which it was capable.* In 1821 there were 24,581 miles of turnpike roads in England and Scotland, and 8,000 miles in Ireland; and since that time they have much increased.

Paving.—When the turnpike-road system was introduced, the pavement of the metropolis was improved by the substitution of square blocks of granite, in place of the rounded boulders, or large irregular pebbles, which had been previously used. Blocks of granite of various dimensions, have, by way of experiment, been laid on concrete, with the joints grouted with lime and sand, in order to insure the greatest stability amongst the blocks. M'Adam's system was introduced in some streets where the traffic was light, but it did not equal the granite paving. Wood blocks in different forms, hexagonal prisms, or cubes, or rhomboids, with the grain placed vertically, or nearly so, have been introduced for paving, the blocks being either connected by wooden pegs, or merely laid upon a bed of concrete. This system was borrowed from Russia, and patents have been taken out by Stead, in 1839, and many others, for different forms of the blocks; it has the advantage of diminished ncise and friction, but its great defect is that of being dangerously slippery in particular states of damp weather, and it appears in consequence likely to be abandoned. Asphalte, a natural brittle, bituminous substance, found in volcanic districts, was introduced from France for foot pavements, in 1836; it is brought to a semi-liquid state by heat, then mixed with sand and gravel, and spread over a bed of concrete, and when cold, forms a compact and durable pavement. Flats, or flat gritstone paving-blocks have been used in larger blocks, and better laid, so that paving has been improved; the great difficulty, however, in keeping it in order in London and great towns, is occasioned by its being constantly broken up, to lay and repair the numerous gas and water-pipes; and it is desirable that separate tunnels or subways should be employed for receiving them, as was suggested by Williams and others, a few years since.

* The transport of goods was equally defective as to speed, and was comparatively as costly as that of passengers; at times, goods were from four to five weeks, and seldom less than thirty-six hours in going from Liverpool to Manchester, at a cost of forty shillings per ton; whereas at present they are conveyed in three or four hours, for three shillings per ton.

(To be continued.)

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

SOCIETY OF ARTS, LONDON.

February 3.—W. F. Cooke, Esq., V.P., in the Chair.

Mr. Digby Wyatt read an Essay "*On the Art of Mosaic, Ancient and Modern.*"—The author commenced by stating that the most cursory glance at the subject must convince that this art, taking the form of either pavement or mural decoration, has been connected with most of the noblest efforts of architectural genius at all ages; and as it is the wish of many at the present time to effect the revival of this art, he would endeavour to convey as clear an idea as possible of the nature, history, and condition of this graceful handmaid to the science of decoration.—The first positive notice of the existence of such an art occurs in the 6th verse of the first Chapter of the Book of Esther, wherein an account of the riches and luxury of the Palace of Ahasuerus is mentioned, and that passage clearly establishes the fact that the Persians were acquainted with the art, and it is supposed communicated it to the Greeks, from whom the Romans obtained their first specimens. Ciampini divides the art into four principal varieties, called tesselatum, sectile, figlinum, and vermiculatum. The first, the opus tesselatum, probably the most ancient; this kind of mosaic consisted of small cubes of marble, seldom averaging more than ¾ of an inch square; the best specimens of this description of tessela occur at Pompeii, in the Vatican. The second division of the art, the opus sectile, was also applied to pavements, and it is in this description of mosaic that the simple yet magnificent pavement of the Pantheon at Rome is executed. This variety of mosaic was formed of thin slices of different coloured marbles, cut into slabs of a given form. The opus figlinum was more generally employed in mural decoration, and according to Pliny, was first used in the decoration of the baths of Agrippa, behind the Pantheon; it consisted of figures, fruits, ornaments, &c., by means of small cubes of vitreous composition, composed of allumine and some metallic oxide to colour it. No specimen of this description of mosaic has ever been discovered in England. The fourth description of mosaic, or opus vermiculum, is subdivided by Ciampini into three varieties. The opus major generally employed in large pavements or ceilings, to represent the figures of gods, centaurs, &c. The opus medium was a much finer kind of work, and was generally applicable to walls. The third division, opus minor or opus vermiculatim, was the finest and most elaborate of all the ancient Roman mosaics, and consisted of the most delicate patterns, formed entirely by mosaic pieces of marble and fictile work, many of the stripes being only the 20th of an inch across. The most beautiful specimen that has been presented to us is the one usually known by the name of Pliny's doves (a copy of which in mosaics was exhibited). There is one kind of mosaic which the author has observed in Pompeii, and which he considers may not be inaptly termed the opus uncertain of mosaics, composed of all sorts and kinds of marbles put together in singular shapes, and when united into a mass with cement and laid on the floor prepared to receive it, it is reduced to a polished face by friction. In completing the sketch of this art under the Romans, the author stated that the preparation ordinarily made by them for the reception of the mosaics, consisted in their first placing a layer of large stones or flints, but with very little cement, on the ground; upon this was placed a course of concrete composed of smaller stones and lime beaten and rammed with great care; upon this a third layer of cement was placed, the tessaræ or mosaic were then placed, and over the whole was poured liquid cement, to perfectly fill up the interstices between the cubes.—During the reigns of the twelve Cæsars this art rose to an unexampled popularity; during the reign of Hadrian, (A.D. 138) to that of Caraculla, the arts appears to have lost in quality; after the year 220 it became obscured by the clouds which swept the Roman empire.

From the time of Constantine three varieties arose, which obtained universally in Italy from the 4th to the 14th century, and during nearly 1000 years changed but little either in principle or design. The Emperor Alexander Severus (A.D. 222 to 235) brought with him from Alexandria great quantities of porphiry and sepentine, which he caused to be worked into small squares and triangles, and variously combined, thereby laying the foundation of this art which formed the pavement of all the rich Italian churches. We have an interesting specimen in Westminster Abbey referred to the year 1260.

The author, after tracing the history to its decline, and giving some account of the encaustic tiles, proceeded to state the circumstances which had of late years led to its partial revival; he also gave a detailed description of the processes of manufacture employed by Messrs. Singer and Pether, and Messrs. Minton and Co., and concluded by urging on architects and the public generally the applicability of the manufacture to the purposes of decoration.

The meeting adjourned after passing a unanimous vote of thanks to Mr. Wyatt for his communication.—The rooms were filled with beautiful specimens of ancient and modern works of art in mosaic. There were some fine Florentine mosaics contributed by Mr. Brown; modern glass mosaics of exquisite workmanship executed by Mr. Pether and Mr. Singer; encaustic tiles by Mr. Blashfield; mosaic tesseræ by Messrs. Minton; and a large collection of elaborate coloured drawings contributed by Mr. Blashfield, Mr. Wyatt, and Mr. Owen Jones.

ROYAL SCOTTISH SOCIETY OF ARTS.

Jan. 25.—David Maclagan, M.D., F.R.S.E., President, in the Chair.

The following communications were made:—

"*Description of Pottery made by the Ojibbeway Indians, with an account of a Chemical Analysis of fragments of it.*" By John Macadam, Esq.

The Pottery exhibited before the Society, and referred to in Mr. Macadam's paper, was obtained from the neighbourhood of Peterborough, Canada West. It is of a brownish black colour, the outer surface being reddish It is exceedingly hard and difficult to fracture. The vessel is ornamented around the edges with a design evidently copied from nature, and somewhat resembling a pinnate leaf, besides which the surface is almost totally covered with a scratched-like net-work; indeed, the design as a whole resembles much that which exists on the pottery occasionally found in the Druidical tumuli of our own country. There are small crystal-like particles distributed throughout its mass, which vary in size from one-fiftieth to one-twentieth of an inch in diameter. These particles are pure silica, and were probably obtained by pulverising quartz or some other natural variety of silicic acid. The pottery also contains organic matter to a considerable extent, which is of vegetable origin, and was added, no doubt, to this with the same intention as straw was added to the Babylonian and Egyptian varieties of sun-burut pottery, viz., for the purpose of increasing the adhesiveness of the particles. A portion of the pottery submitted to chemical analysis gave the following results:—

Water	1·86
Organic matter	5·92
Silicic acid	64·80
Sesqui-oxide of iron	14·30
Alumina	9·95
Lime	4·39
Magnesia	1·43
Potash and Soda	traces.

The amount of oxide of iron stated is rather high, as the iron present, though calculated as the sesqui-oxide, does not exist as such in the pottery, but is there, almost totally, as the protoxide, except in those parts of the pottery which possesses a red colour.

From the results of the investigation made on this interesting piece of manufacture, some conclusions were drawn to the following effect:—First, that the pottery had probably not been made by the use of any one material found native, but was manufactured from a mixture of pulverised silica, ferruginous clay, and organic matter; secondly, that the heat employed for baking the pottery, when made, was one of no high temperature, as, had it

been so, the protoxide of iron would have been thereby converted into the sesqui-oxide; and, moreover, all the organic matter would have been destroyed. The red appearance on the outside of the vessel indicated its having been baked at a common wood or other fire, the influence of which being in contact only with the outer surface, had confined its chemical action to that part.

Description and Drawing of a Sluice made by Mr. JAMES MACDONALD. The sluices commonly in use are raised from the bottom, thereby causing a rush of water, which injures the puddle of the pond, or aqueduct, and are raised and shut with difficulty. Those of a better construction are expensive, and can only be made by skilful persons. This sluice can be made by any carpenter, never disturbs the puddle, and may be made of any size and strength by increasing its proportions. The coarsest undressed timber may be used, except the edges of the planks and their ends, where they fit into the frame. A strong frame of wood is built into the sides of the water way, tapering from the bottom, where it is narrowest, to the top. Planks are let in, one above another, to the required height; and if it be wished to increase or diminish the height of water in the pond, it is only necessary to put in, or to remove a plank at the top; the water thus always escaping from the top of the sluice in place of from the bottom.

Feb. 8.—GEORGE TAIT, Esq., V.P., in the Chair.

The following communications were made:—

Description of Four Portable Apparatus for Inhaling the Vapour of Sulphuric Ether; with some remarks on its effects, so far as they have been observed in this early stage of its application, as an anodyne to relieve the pain of surgical operations.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.

Feb. 8.— BELLAMY, Esq., in the Chair.

A paper on "*the Interior forms of Buildings with reference to the Laws of Sound*," by Mr. SCOTT RUSSELL, was read.—Mr. Russell, in commencing his remarks, said, in excuse for interfering with what might be considered not his province, that although extreme division of labour might, and did, carry science forward, yet, by confining particular departments to classes, it induced narrow views. He thought much good resulted from the professors of different sciences mixing together and interchanging opinions. It was difficult to excel in more than one, still there were many examples of those who had done so,—as Michael Angelo, Leonardo da Vinci, and others. If in anything extra-professional aid was needed by architects, it was in the arrangement of buildings with reference to the transmission of sound, where all were avowedly at fault. All architects admitted that nothing was more difficult. Mathematicians, when applied to, gave widely different forms as the best. Even an ear-trumpet was no better made by the most profound mathematician than by the merest rule of thumb; and if it were so difficult to arrange an instrument by which sound might, with every advantage, be conveyed to one individual, how much more so must it be to arrange a room so that every one in it might hear what was said. The problem was to enable 1 or 1,000 to hear equally well. The waves of sound were generally thought to be like the waves of water: he had been led to investigate the latter, and, in so doing, had arrived at some conclusions not generally entertained. He proposed to divide the subject into five parts. The first principle to be mentioned was this that sound travels in straight lines: light and sound are the same in this respect. Sound does not easily go round a corner; and this should be remembered in arranging buildings. The question was how to make the greatest number hear and see well. In the theatre of the Royal Institution in Albemarle-street this had been successfully worked out: he thought that from every seat in it the lecturer could be most distinctly seen and heard. This was arranged by Count Rumford and Sir Humphrey Davy. The human voice, the lecturer remarked, could be heard 500 feet with ease; and he believed that a building might be arranged to seat 20,000 persons where all would hear: the fact that Wesley, preaching in a natural amphitheatre of hills, was heard by that number of persons, justified his opinion. He had noticed that a reader in the choir of Canterbury cathedral could be heard 200 feet off distinctly, and afterwards making the experiment himself with a friend, had found that he could be heard that distance when he spoke in a clear whisper.

Mr. Russell then proceeded to explain a curve which he had discovered, and recommended for the sectional arrangement of the seats, and the mode of obtaining it, but which we find it difficult to convey without diagrams. It was first necessary to fix the position of the speaker, and to decide how much of the voice and sight of the speaker each auditor should have; he thought an area 18 inches high and 3 feet broad sufficient. Drawing then a series of radial lines from the mouth of the lecturer to points decided by these dimensions, a curve was obtained for the rise of the seats, which was found in practice of good effect.

The second principle he would allude to was the spontaneous oscillation of air in a chamber, which was the source of much trouble, but might be turned to good account. A long chamber of air, if caused to oscillate, continued to do so, and would produce a tone depending on the length, as in an organ-pipe. Thus a gallery, 64 feet long, would produce the note C; and if 32 feet long, it would be an octave higher. Every chamber, in short, has a voice. A speaker should find out the key-note of the room, and speak in it if possible. This fact opened the question whether we could improve rooms for hearing by attention to the dimensions and proportions. Length, breadth, and height should be in harmonious proportions, or the sounds produced would jar. There was a more intimate connection between music and architecture than is now generally admitted. Simple multiples for the proportions were desirable; as, for example, 48 feet long, 24 feet wide, and 16 feet high, and so on. Incongruous sounds, he said, neutralise each other, and produce dead points, or points where the speaker could not be heard. Care was necessary in this respect. Harmonious arrangement of an apartment might sometimes be obtained by means of pilasters, or partition with doors. The choirs of our cathedrals usually approximated to simple multiples in their proportions, and bore out his view, he thought, by their effects. Incongruous forms made the worst apartments for hearing. The lecturer was then proceeding to speak of the third division of his subject, reflection of sound, but was invited to postpone the consideration of it till the next meeting.

Feb. 22.—S. ANGELL, Esq., V.P., in the Chair.

The following Report of the Council on the Design and Essays submitted for medals was read:—

Report of the Council to the General Meeting of the Members on the Designs offered in competition for the Royal Medal of the Institute, for the Soane Medallion, and on the Essays submitted for the Medals of the Institute for the year 1846:—

The Council have to report that for the Royal Medal, the subject being a building suitable for the purposes of the Royal Institute of British Architects, eleven designs have been received. They deem it proper in the first instance to advert to the printed conditions prepared for the guidance of the competitors, and which were issued in May last.

Her Majesty the Queen having been graciously pleased to grant to the Institute an annual medal for the promotion of architecture, it has been resolved, that it shall be applied to the encouragement of the junior members of the profession by a competition in designs, composed in a style calculated to promote the study of Grecian, Roman, and Italian architecture, and further, that the designs shall be judged of, not only with reference to their merits as works of art, but likewise as to the knowledge of construction they may exhibit.

In order to secure, as far as possible, uniformity in the conditions under which the designs are submitted in competition for the Royal Medal, it has been determined that the age of the competitor shall be limited to twenty-five years, and that with this limitation the competition shall be open to the profession in general.

The successful competitor will be further intitled to draw upon the Treasurer of the Institute for the sum of £50 after his arrival in Rome in the pursuit of his professional studies, at any period within five years from the time of the medal having been awarded to him, upon sending to the Institute a satisfactory study of some existing building, either ancient or modern.

The Royal gold Medal for the year 1846, will be awarded to the best design for a building suitable to the purposes of the Royal Institute of British Architects; comprising a room for general meetings and lectures, with seats for 350 persons, arranged with a view to the reading of papers, the exhibition of drawings and diagrams explanatory thereof, and for facility of discussion; a council room for twenty-five members; a library for 10,000 volumes, with suitable depositories for drawings, prints, medals, &c.; a gallery for models, casts, fragments, &c.; an exhibition room for architectural subjects, and suitable residences for a secretary and a curator.

The cost of the building not to exceed £20,000.

The design to comprise not less than one plan of each story,—two elevations, two sections, and a perspective view.

The scale of the drawings to be one-eighth of an inch to the foot, and to be tinted with Indian ink or sepia only.

The Council will not consider themselves called upon to adjudge the medal, unless the designs and drawings be of sufficient merit to deserve that distinction.

In detailing thus minutely the accommodation to be provided in the building, to render it suitable for the purposes specified, and by fixing a limit to the proposed expenditure, it was obviously intended by the Institute to impress the candidates with a feeling that in forming their designs they were expected to treat the subject practically, and direct their efforts to the production of a design adapted to the requirements of an existing working Institution.

They observe, with much regret, that the well considered and clearly expressed conditions of the Institute have been almost entirely disregarded, and that in consequence of the uncalled for magnitude of the rooms, halls, staircases, and other approaches, together with the lavish and injudicious introduction of columnar and other extraneous decoration, (in some instances actually unfitting the rooms for the purposes demanded), not more than one of the designs, possessing the slightest pretension to consideration as an architectural composition, could be properly executed for less than *double the sum specified*.

When the Council reflect on the enormous amount of injury occasioned to the public and to the profession, from competitors so frequently disregarding the conditions given with respect to the proposed expense of an intended structure, and consequently presenting designs of much higher pretension than could be produced with an honest and conscientious adherence thereto. And when they likewise reflect on the strong reprobation the Institute has had occasion more than once to express on this most irregular and improper practice, they feel that it would ill become the Council to recommend to their fellow-members of the Institute to countenance such dereliction from honourable professional practice, even in a competition like the present one, where the public interests are not directly affected. The fact being so apparent, entirely precludes the Council from recommending to the members of the Institute the awarding of the Royal Medal to either of the designs presented this year.

They regret to be compelled, on grounds which they consider too important to be disregarded, to come to this decision, especially on the first

occasion of a competition for so high a distinction as the Royal Medal, and the more so, since the design marked "Quanto rectius hic qui nil molitur inepte," possesses a high degree of merit, and displays much taste and artistic talent.

The Soane Medallion for the year 1846, was offered for

the best design for an edifice, suitable to the congregational worship of the Church of England, and capable of accommodating 1,000 persons, without galleries.

The design to be Roman or Italian, expressive of its purpose both internally and externally, presenting as little obstruction to sight as possible. The chancel to be properly marked in plan and decoration, with reference to its Protestant uses. All the windows to be charged with stained glass.

There must be a conspicuous belfry, but the body of the church is not to be surmounted by a dome.

The drawings of the elevations and two sections, to be to a scale of one-quarter of an inch to a foot,—the plans and perspective view to one-eighth of an inch to a foot, and tinted with India ink or sepia only.

The competition is not confined to the members of the Institute, and the Council will not consider themselves called upon to adjudge a premium, unless the drawings be of sufficient merit to deserve that distinction,—

and for which, two Designs have been received. The Council most reluctantly observe that they do not consider either of them as deserving of the reward offered.

Three Essays have been received "on the adaptation and modification of the orders of the Greeks by the Romans and moderns."

The Council are of opinion that the Essay marked by the motto "Hœ tibi erunt artes," is distinguished by considerable research and knowledge of the subject—the style is clear and unaffected, and the reasoning good. The Council consider that the treatment of the subject is somewhat too historical, and that not sufficient attention has been paid to the various social causes which operated in effecting the modifications of the orders. The Council are of opinion that this Essay stands first in the order of merit, and is well deserving the Medal of the Institute.

The Essay marked Θ, evinces considerable study and able treatment of the subject, the Council therefore recommend that a Medal of Merit be awarded to this production.

For the medal offered by the Institute for the best Essay on Drainage, viz.:—

On the best system to be adopted with regard to the arrangements for the thorough drainage of a town house, and of a nobleman's mansion and offices in the country, respectively. Comprising the general arrangement for carrying off the waters and sewage, the sizes and most convenient forms for the drains or conduits, the requisite fall, the description of material to be employed, and the several precautions for the prevention of damp, smell, and passage of vermin;—to be accompanied by block plans and details,—

one Essay only, accompanied by two plans marked "Hygeia," has been received.

On a careful perusal of the Essay, it appears that the author has not treated the subject in the terms of the programme; that he has neglected the main subject proposed, and altogether omitted those details to which his attention was directed by the published particulars. The writer has shown much diligence, and some knowledge of the matter on which he has treated, but this also is in too general a manner, and upon points not properly within the scope proposed by the Institute.

Under these circumstances the Council cannot recommend the medal to be awarded to this production.

The sealed papers being opened, the chairman declared the names of the successful candidates: for the Silver Medal, W. John Woody Papworth, of 10, Caroline-street, Bedford-square, Fellow; for the Medal of Merit, Mr. James Bell, Associate.

The Essay which gained the Medal of the Institute was then read by the author; it commenced by arguing that Hellenic Art, when introduced by Cossutius at Rome, was corrupted by the influence of a previous style, in the same manner that the architecture of Alberti was degraded, through a Gothic feeling, into the Elizabethan, the Renaissance, and the Tedeschi variations. Treating of the remains of the Etruscans in art, he repudiated the testimony of their vases, and held that they exercised little influence on the early style of the Romans, which he considered to be Alban or Latin; he used that term to denote the simplest order of Classic Architecture, which was gradually superseded in Rome by the Ionic and triglyphed Doric. In justification of an original table which dictated the employment of Corinthian columns only when in height exceeding fifty feet, and gave average heights to each order, ending with only eleven feet allowed to the Latin Tuscan, the author appealed to several tables of calculations, which showed that according to his formula, passages of equal widths between pairs of columns, of each order, of one diameter, demanded lengths of architraves not exceeding the powers of the simplest mechanical construction; and greatest when capping the highest columns: whereas the usual acceptation of the directions of Vitruvius absurdly tended to show that the greatest lengths of architraves would seem most consistent with the lowest columns, although the ancients always expected narrowness of intercolumniation and slimness of pillar to accompany each other.

The most important modifications made by the Romans, while retaining the scientific conventionalities of the Greeks, and adopting the Eustyle intercolumniation, and the pseudodipteral and hypaethral arrangements, consisted in the proportions of their plans and in the positions of their columns; in the proportions of their entablatures, and in the contour of the mouldings; in the use of square columns, often allowed to be predominant, and in debasing the circular pillar to a mere pilaster, and to the practice of supercolumniation.

Reference was made to a drawing exhibiting a moiety of the same building in each style, entering into a comparison of the different results accompanying various coincidences, and stress was laid upon the sentiment of a rectangular and statuesque simplicity visible in nearly all Greek edifices, in opposition to that of curved and picturesque grouping in the enlarged sphere of action of the Roman imperial artists.

The author defended the revivalists for establishing a standard for each order, on the ground that they were justified in suspecting all the antiques (of which they really saw very little) to be barbarous, and in trying to bring them to a correspondence with Vitruvius,—each publishing his own idea of perfection, in which the great masters were wonderfully agreed: and exposed the fault of making their illustrations formulæ—to be applied without change on any occasion, at any height, in any situation, for any purpose. He examined the practice of the great masters and the pupils in the several modern schools, and mentioned, in a list of their additions to the store of the architect, the use of the niche, of pedestals, of balustrades, of sculpture (of all sorts) as mere decoration, of the araeosystyle disposition, of the basement and attic stories as features, of spires and steeples and bell towers, and of an extraordinary luxury of internal and external architecture.

The paper closed with the observations that, with Chambers, Mylne, Dance, Holland, and Soane, expired the race of architects in one style only—but in a style of which they were masters; their successors being condemned, by exposure to the caprice of patronage for a command, to summon up the resources of any style—to clothe even an impracticable idea; and that the current of taste was undeniably tending towards an art altogether different from that of Greece in its construction, or else to that of Palladio and Chambers.

INSTITUTION OF CIVIL ENGINEERS.

Feb. 2.—Sir John Rennie, President, in the Chair.

The Institution met for the first time in the new theatre, and a paper by Mr. W. E. Newton was read, giving a description of the method employed by Mr. Herron "*for the construction of the permanent way of the Philadelphia and Reading, and other railways in the United States.*" The method was a deviation both from the systems of the longitudinal and the transverse sleepers, crossing each other and spiked together at the intersections with wooden trenails or iron pins, acording to circumstances, forming an extended platform, upon which their longitunal bearers were laid, supporting bridge-shaped rails with wrought iron chairs. The paper gave an account of several deviations from the general system, such as making the trellis-work of iron laid in bitumen, &c., and also a detail of the amount of traffic conveyed along the railway; whence it appeared, that within one year and five days from its being opened for general use, 1,400,000 tons of goods had been conveyed along it, without any prejudicial effect, and, in fact, with less wear and tear than was usual upon railways in the States. The cost of a single line of permanent way was about £850 per mile. From the discussion that ensued, it appeared to be the opinion, that although the system might succeed in a country where timber abounded, it was inapplicable for English railroads; and exceptions were taken to the general features of the construction for high speed, as the rails, which weighed only forty-four pounds per yard, and which were of a bridge form, could not resist the impact of the wheels at great velocity: the junction of the diagonally laid sleepers would become loosened, and there would be too much deflection between the bearing points.

Feb. 9.—Sir John Rennie in the Chair.

A paper was read on the "*Helder or Great North Holland Canal*," by Mr. G. B. W. Jackson, Associate. This canal was constructed by the late Mr. J. Blanken, engineer, during the six years between 1819 and 1825, for the passage of frigates and first-class merchantmen, and extends from Amsterdam to Nieuwediep in the Texel. The state of the navigation through the Zuyder Sea, in the early part of the 17th century, having become so defective, in consequence of accumulated sand-banks and shoals, that camels were necessarily made use of to lift the vessel over the shallows at Pampas, thereby incurring both extreme loss of time and inconvenience, the Dutch Government deemed it necessary to consult Mr. Blanken on the possibility of remedying the evil. That engineer accordingly projected the above canal, which has three divisions, the summit level being only 3 feet 8 inches above the outlets. Its length is fifty-one miles. It is 123 feet 7 inches broad at top, 30 feet 10 inches at bottom, and 20 feet 6 inches deep. The pile-driving and boring experiment undertaken by him to ascertain the probability of success, show that the original sea shore, being the only really hard ground in the north of Holland, is to be met with at 43 feet under the present surface of the ground; and as the foundations of the locks were laid nearly at that depth, the result of the experiment was considered to afford sufficient guarantee for the stability of the works. The character of the soil in that part of Holland is exceedingly treacherous, and it reflects great credit on our foreign neighbours that they were able to overcome the various difficulties with which they had to contend.

The constructions generally consist of floating and swingbridges, tidelocks, passage-locks, &c. The floating bridges are peculiar on account of their flexibility, consisting of two platforms, one fixed to each shore on piles, the end of each of which is worked by sets of double levers and rest-

ing on two boats, so that when the bridge is required to be opened, both boats are withdrawn, one towards each shore. The Willem lock is 297 feet 8 inches long, 51 feet 5 inches wide; the height of the lock walls being 32 feet 0 inches, and the gates being each 29 feet 5 inches by 29 feet 4 inches.

The total cost amounted to one million and a half pounds sterling. The time required by vessels to make the passage from Amsterdam to the Helder varies according to their size, and the means of haulage; fly-boats, with six relay of four horses each, making it in ten hours, whilst large East Indiamen require two, three, and four days, according to the wind. The details of construction of the whole of the works were given very freely and with illustrated drawings. In the discussion which ensued, it was stated that the only canal in this country which could be contrasted with that of the Helder, was the Caledonian canal, which was projected upon a report by Watt, commenced by Jessop, and in a great part constructed by Telford, a few years previously to the Helder canal. The principal difference between the two consisted in the nature of the ground through which they were cut, the former being excavated entirely out of alluvial deposit, whilst the latter had to be cut out of hard gravel, and in some cases rock. An interesting account was given of the mode of forming the spot for the entrance-lock at the Inverness end of the Caledonian canal. The object was to carry the work out into deep water. A large mass of earth was deposited in the sea to the full extent intended. Upon this mound, a heavy load of material was laid to consolidate the mass. After settling for a considerable time, the upper mass was removed, the excavation was made for the lock-pit, and the construction was effected with comparative facility, and had endured much rough weather since, without any symptoms of failure. The superincumbent weight which was removed, being greater than any subsequent strain, there was no danger of the lock ever sinking.

On the 16th inst., this paper was continued, and treated principally of the art of building with fascine work, as practised in Holland and Germany.

The usual construction of these dykes was described to be, by sinking successive layers or beds of fascines or faggots of almost 30 inches thick by from 8 to 16 yards in width, and of proportionate length, weighted with gravel and stones mingled with clay, sea-weed, and silt. These layers were continued until they reached above the sea level, when the top was constructed of more solid materials, and sometimes capped with brickwork, as the public roads were formed upon them.

The slopes of the faces of the dykes vary considerably: some of the low dykes are in section of the form of an arc of a circle of 6 to 10 feet chord and 10 inches to 1 foot versed sine, covered with fascine matting, staked down upon a clay-bed. Others have a base of 19 feet wide and 5 feet of a triangular section, also made up of fascines and stakes, secured by hurdles and wattling, with clay, peat, sea-shells, and sand, well rammed in, and then covered with turf. Others are formed with rows of piles, 16 feet long, with their heads 6 or 7 feet above the shore, joined longitudinally and laterally by waling timber, filled in and around with fascine beds and weighted with stone. Baskets filled with sand are also used in certain situations, as well as various modifications of all these kinds of protections. It was stated that these constructions were found to succeed better and last as long as stone, being at the same time about half the cost.

ON GUNPOWDER.

Dr. Faraday, in a lecture delivered at the Royal Institution, gave some account of the "*Composition and Qualities of Gunpowder.*"—Its composition contains 75 parts of nitre, 15 parts of charcoal, and 10 parts of sulphur; which, converted into equivalents, give 1 of potassium, 1 of nitrogen, 6 of oxygen, 3·4 of carbon, and 0·85 of sulphur, in a state of mechanical mixture.

The Action of Gunpowder.—Gunpowder is a solid body, in which a source of enormous power is locked up, capable of being brought into immediate operation whenever wanted: the action thus elicited being itself regulated by human skill with wonderful precision. The enormous quantity of gas generated by the combustion of gunpowder, irrespective of heat, was exhibited. It was remarked that, on the ignition of gunpowder, though the sulphur begins the combustion, it is not itself burned by the oxygen of the nitre, but unites chiefly with the potassium of that salt to form sulphuret of potassium, a substance which assists in giving to the flame of gunpowder an intense heat. If gunpowder and steel filings be dropped together through four or five inches of flame, the latter will burn, though the former will not. A flame from gas was made to play for several seconds on a heap of gunpowder, without lighting it; but when actually lighted, it evolves very great heat. It is to the immense heat produced on the solid products of the combustion of gunpowder, that the certainty of its complete combustion is greatly owing. In this respect gunpowder differs characteristically from gun-cotton. The latter fires at a heat which would not affect the former; but produces, by its combustion a degree and condition of heat much less communicable to other bodies. The effect of the heat generated, independent of the chemical change from the solid to the gaseous or vaporous state, was illustrated by the violence with which a mixture of one volume of oxygen with two of hydrogen gas bursts the vessel which contains it, solely in consequence of the heat elicited during their combination. This is manifest from the fact that the space occupied by the uncombined gases is greater by one-half than that taken by the resulting steam.

Granulation.—Prof. Faraday laid great stress on the effect of the granulation of gunpowder. To this condition of gunpowder, presenting, as it does, a number of separated surfaces of size just sufficient to become surrounded with flame at the same instant of ignition, much of the disruptive or projectile effect of gunpowder was ascribed. It was shown that, without that porosity which its division into grains imparts to a mass of gunpowder, the explosion of the whole could not be instant nor simultaneous. This was proved by bringing a piece of mill-cake successively into the condition of grain powder and of meal powder. The slow combustion of the solid meal powder fuse was compared with the quicker inflammation of the hollow rocket and the instant inflammation of the charge of a gun. All these effects are related to the condition of the interior of the gunpowder in respect of its permeability by the flame of the first particles ignited. Then, as to its exterior condition, it was shown that the tardy burning of the miner's fuse is due to the granular state of the powder in its case being counteracted by the pressure of the strands of rope wrapped very tightly round it; while, on the other hand, in the cracker of the firework-maker, a similar train is instantly fired throughout, because it has a loose jacket all over it, and, in the burning of the common cracker, an alternation of these effects is produced.

The great importance of Time in producing the effects of Gunpowder.—Contrasting the action of gunpowder with that of fulminating mercury and silver, or of those still more fearfully explosive compounds, the chlorides of nitrogen and of iodine, Prof. Faraday showed, that, if the explosion of gunpowder were really instantaneous, it would be useless for all its present applications. As it is, however, whenever gunpowder is fired in the chamber of a gun, it does not arrive at the full intensity of its action until the space it occupies has been enlarged by that through which the ball has been propelled during the first moment of ignition. Its expansive force is thus brought down and kept below that which the breach of the gun can bear, whilst an accumulating, safe, and efficient momentum is communicated to the ball, producing the precise effects of gunnery. This manageable action was contrasted with the effect of a morsel of iodide of nitrogen put on a plate, and exploded by being touched by the extremity of a long stick. The parts immediately in contact with the iodide were shattered,—*i. e.*, the end of the stick was shivered, and the spot in the plate, covered by that substance, was drilled as if a bullet were fired through it, yet no tendency to lift the stick was felt by the hand; whereas the comparatively gradual action of gunpowder lifts and projects those weaker substances, wadding and shot, which give way before it.

ORNAMENTAL GLASS.

Mr. Apsley Pellatt delivered a lecture at the Royal Institution on Feb. 12, "*On the manufacture of ornamental glass.*" He explained that the refractive pellucid colourless brilliancy of flint-glass was owing to the presense of lead; and that flint-glass, or more properly glass of lead, most resembled rock-crystal or the diamond; and in this branch of the trade, especially as regarded table and chandelier glass, the British glass-manufacturers were pre-eminent, and superior to their continental rivals. The entire manipulation in the making of a wine-glass, jug, barometer-tube drawing, patent pillar moulded vase, were explained in detail both from large diagrams and from the practical exhibition of these processes by two workmen; a furnace having been fitted up by Mr. Pellatt in the theatre of the Institution for the express object; also salt-cellars were pressed by machinery, bottles blown and moulded, spun-glass drawn, &c. During these operations Mr. Pellatt explained the conditions of whetting off by the application of the sudden contraction of the cold iron tools, so that a slight blow would separate the bowl of a wine-glass from the glass adhering to the blower's crow; that a punty might be applied to the reverse end for shearing and finishing the bowl. The punty is a solid iron cane, with a little hot glass adhering to it for handling glass pieces; which, by partial melting of the glass in the course of manufacture, is again removed by a tap when it is no longer required. The peculiarity of glass welding by contact (impossible if the slightest film of sulphur intervene), and various manipulations, were detailed, particularly the projecting moulded pillars which possessed the refractive and brilliant effect of cut glass; and although invented and introduced a few years since by Mr. James Green as a novelty, it was found, on comparison with a Roman specimen of glass dug up in the city of London, the property of Mr. Roach Smith, apparently to have been manufactured by means of the same appliances as the ancients, the fragments having a perfectly even interior, with a projecting pillared exterior.

The difference of glass made by hand and in moulds was stated by the lecturer, as well as the distinction between moulded blow-offs with cut scolloped edges, which were far superior in the interior polish, as contrasted with articles, such as dishes and salt-cellars, pressed in moulds by mechanical power, as introduced by the American system, whose interior

surfaces were uneven and ruffled, by the metal plunger not always being kept sufficiently hot. An ingenious cylindrical vial mould, for blowing bottles without seam, of uniform sizes, was used; and bottles were manufactured both from it and the ordinary open and shut moulds, which will be polished and clean blown, provided the inside of the moulds are kept at nearly the same heat as the temperature of the glass blown in them. The elasticity of glass was exemplified by glass balls of about three inches diameter rebounding from a polished iron slab three-fourths of the height from which they were dropped, as well as by blowing glass so attenuated as to be sustained some short time floating in the atmosphere; this is technically called glass frost. Annealing and its effects were briefly stated. The process of casing (called by the French *double*, *treble*, &c.) colours upon white glass was then practically shown by the workmen, who covered a white glass toilet-bottle with blue, about the thickness of an egg-shell; and Mr. Pellatt displayed a vase of the exact size and shape of the Portland vase, manufactured at the Falcon Glass-works with a thick interior coating of dark blue glass, upon which a thin white enamel of glass casing was laid; his engraver had cut away parts of the white, leaving masses of blue in the neck and upper part of the vase exposed to view, and had chased out at the lathe, with the engraving tool, a portion of the bas-relief.

A full size drawing of a double-handled vase, without foot, now in the Museum of Naples, was exhibited, made of blue glass, and cased with white enamel, with handles, from which were engraved in relief, an elaborate arabesque subject, with a group of Bacchanalian boys under each handle. In design and artistic power it is considered by Zahn as second only to the Portland vase. This vase was found in Pompeii in the year 1837. Mr. Pellatt stated that Mr. Wigel, the celebrated gem-engraver, had expressed a desire to make an exact copy in glass of the Portland vase, provided he could set apart adequate professional time for the object; and Mr. P. expressed his determination to aid this patriotic intention, pledging his Firm to its execution, so far as regarded the manufacture of the crude vase. This species of engraving in relief, probably took its rise among the Greek and Roman artists, in imitation of real bas-relief gems. Many rough and unfinished specimens are to be seen in the British Museum. Modern engraving of rough patterns upon transparent glass cannot be traced earlier than the Venetians. A lathe, a copper wheel and emery-powder for the rough grounds, and a lead wheel for polishing, are the engraver's tools. Specimens were on the table, as worked by the lathe. Glass-cutters' iron wheels for cutting, used with wet sand; stone wheels, used for smoothing with water, and wood wheels for polishing with pummice, and afterwards with putty powder, were slightly explained from the specimens exhibited. Flint-glass decanters, roughed, smoothed, and polished, were shown; also four polished cut decanters, of one uniform shape and size, but varying in strength, to exemplify the difference of brilliancy; that with ten faces of flutes on the cylindrical body being least refractive, and that with six faces or fluting being most refractive; and the eight fluted and ten fluted ranging between the two extremes in refractive effect; the condition of pellucid refractibility depending upon the greatest projection of angle, in proportion to the greatest quantity of flat surface cut away from the exterior of the cylinder (the interior remaining circular). The last glass manipulation of the workmen was drawing Venetian filigree cane. Threads of white and coloured glass were placed vertically around the extremity of the interior of a brass mould; a solid flint-glass ball was blown into the interior of the threads, welding the latter to the outside of the ball, and drawn as tube and cane is usually drawn, except that each workman twisted in an opposite direction, as they retired from each other to lengthen and attenuate the filigree cane; which, being whetted off into such lengths as may be required, is afterwards used for wine-glass stems, or made up into vases, pateras, and other filigree objects of taste. Specimens of mosiac glass were also shown and explained, by which, pictures, as described by Winkelman, were made, by welding lengths of small cane to each other, the patterns being previously sectionally arranged to required variety of colour, &c.; so that when massed together by fusion, the whole shall appear homogenous. These are cut off into slabs at right angles to the length; so that the subject or pattern is repeated on each slab. Venetian millefiore glass was explained to consist of single canes of filigree glass, cut off into small lozenges, and placed side by side, and welded to white flint-glass, forming a sort of mosaic work. The manner of making schmeltz and *vitro de trino* was slightly alluded to, and Mr. Pellatt stated that he had tried to imitate the projecting crystal forms divided by concave fissures of the Venetian frosted glass, and had failed, as he had plunged the manufactured article while hot into cold water, which only dislocated the interior particles of the glass, leaving the surface nearly smooth; whereas his friend Mr. Green had chilled the glass in water in the earlier process of the manufacture, which being afterwards rewarmed at the furnace and expanded by blowing, separated the crystals from each other, leaving the fissures between identically with the Venetian; apparently full of fractures, but really whole and entire. The enclosing of cameos in shut-up pockets was explained. A beautiful specimen of pedestal, with a caryatides enclosure in solid glass, also bricks of glass, with written and composition inscriptions incrusted, were on the table.

Mr. Pellatt concluded by bearing public testimony to the workmen for their willingness and success, notwithstanding the short time of fusion, and the comparative incompleteness of the furnace; and by sincerely thanking the possessors of ancient glass who had kindly lent him specimens, or given him access to their collections.

ON THE NATURE OF HEAT.

Mr. Grove gave a lecture at the Royal Institution, Feb. 5th, on "*some Considerations of the Nature of Heat.*"—After a sketch of the existing theories of heat—the emissive, the ethereal, and the dynamic—Mr. Grove announced himself an advocate of the last, viz. that which regards heat as molecular motion of ordinary matter. The phenomena of what is called "latent heat" have always been considered a stumbling-block in the way of this theory, and a strong argument for the materiality of heat. Mr. Grove considered that all the phenomena of latent heat might be accounted for more simply by the dynamic theory, and that the greatest difficulty in applying this theory was the necessity of excluding ideas associated by long usage with the phenomena, and also of employing terms which had become engrafted by custom on the expansive effects of heat. Thus, in expounding a new view, although more simple in itself than the received ones, we are obliged to avail ourselves of received terms, to which, while we use them, we object. Excepting the case of certain substances which expand in freezing, and which expansion is accounted for by their crystallisation, making the body occupy more space, by leaving interstices between the crystals, Mr. Grove stated that all the phenomena in which the so-called latent heat is concerned were mere expansions and contractions; and that what, according to that theory, would be called absorption of heat, was mere extension of the substance said to absorb the heat. Thus, suppose a given quantity of water to be heated by a given quantity of mercury; the first effect is, that the water expands, the mercury contracts; at a certain point, viz. that at which the water is said to have reached its boiling point, the attraction of the molecules of water is so conquered by the repulsive force, heat, that the water bursts into vapour; here its molecules being more separated, and having consequently a less attractive force, are so much more readily expanded, and exhaust much more expansive force from the heated mercury: this, therefore, loses expansive force, *i. e.* contracts or shrinks; and the more so in proportion to the readiness of expansibility of the substance which robs it of its expansive force. So, if the calorific force be supplied by other means, such as ordinary combustion, say of coal and oxygen, *i. e.* chemical action, the expenditure of fuel will be in proportion to the expansibility of the substances heated; so that the same quantity of water will require the same quantity of heat to convert it into steam, whatever the pressure.

If, again, the same source of heat be applied to the two substances, water and mercury, say to a thermometer immersed in water, both gradually expand, but in different degrees; at a certain point the attractive force of the molecules of the water is so far overcome that the water becomes vapour; at this point the heat or force, meeting with much less resistance from the attraction of the particles of steam than from those of mercury, expends itself upon the former: the mercury does not expand, or expands in an infinitesimally small degree, and the steam expands greatly; as soon as this arrives at a point where circumambient pressure causes its resistance to further expansion to be equal to the resistance to expansion in the mercury of the thermometer, the latter again rises; and so both go on expanding in an inverse ratio to their molecular attractive force. Again, if the steam be not allowed to expand, as by confining it by a less expansive body, say a metallic chamber, then the mercury of the thermometer immediately rises. Thus heat is regarded as a purely mechanical effect; and indeed it can be made to reciprocate with mechanical action. If by mechanical pressure we cause a substance to contract, this gives out heat, *i. e.* causes surrounding bodies to expand; and, *vice versâ*, if we mechanically ratify or expand a substance, cold is produced, *i. e.* contraction in surrounding bodies. The theory was also applied to the increase of specific heat in bodies as their temperature increases, and to many other points; and the whole subject was experimentally illustrated.

Mr. Grove next passed to the consideration of the effects of heat, viewed as repulsive force, upon another mode of molecular attraction, viz. chemical affinity. A vast number of compound bodies are decomposed or resolved into their constituent elements by heat; and these effects may be accounted for by supposing that heat so far separates their molecules as to remove them from the spheres of their affinity. In other substances, however, chemical combination is produced by the application of heat; and though by certain hypotheses these latter effects may also be accounted for by the repulsive action of heat, Mr. Grove seemed to consider these hypotheses rather strained. Water has, up to a recent period, been considered not only undecomposable by heat without the aid of some other powerful chemical affinity, but the elements of water are united by the action of heat; and in pneumatic analyses heat has hitherto been employed to combine the elements of water with each other, or with other gases. Mr. Grove however has proved, and experimentally showed on this occasion, that water is capable of being decomposed by heat; thus forming no exception to the general antagonism of heat and attractive force.

STAINED GLASS.

At a meeting of the Decorative Art Society, on the 27th Jan., Mr. Fildes in the chair, Mr. E. Cooper, "*On Stained Glass Windows*," observed, that a combination of the Italian, or Renaissance, with Gothic embellishment, took place during the reign of Henry VIII., as seen in the chapel of Bishop West, at Ely, and in Wolsey's hall, at Hampton Court, whilst, indeed, the pure Italian architectural design by Torregiano, in the tomb of Henry VII., as well as the windows, carved stalls, and organ-screen, in King's College Chapel, Cambridge, belong to this period. Some fine examples of Italian decorations, in the paintings by Holbein, at Hampton Court, were also referred to. He enlarged upon these circumstances, lest he might be supposed to have anticipated by a century the introduction of the revival more usually attributed to Inigo Jones. A detailed description of the windows at King's College, Cambridge, followed; and the east window of Saint Margaret's church, Westminster, was, in his opinion, designed by the same artist: an examination of this window will convey a correct notion of those at Cambridge. It was said, that this had been executed at Gouda, in Holland; at which place may be seen some of the finest examples of stained glass in existence: they are in the style of the revival, with a considerable portion of white glass in the background, and were painted towards the end of the sixteenth century. Some elaborate engravings of them, just completed by Mr. Weale, were referred to. The eastern window of Saint George's, Hanover-square, is also of this period. Much of the detail was said to be valuable, although a confused effect arises from the ornamental portion overpowering the figures.

Mr. Cooper then remarked, that the windows of the sixteenth century have a peculiar character in the imperfectly attained perspective effects, and the attempts to represent distances by painting; hence exhibiting a departure from the true principles of the art. He observed, that all figures should be supported by draperied or diapered back-grounds, admitting depth in colour. The windows of King's College chapel might be considered beautiful, rather from the rich colours of the glass than from the artistic merit in the application of colours to the design, which can only be made out after some little study. During the 13th, 14th, and 15th centuries, one uniform tone of colour pervaded the back-ground; and as one of the finest examples of this class, the window of the north transept of Canterbury Cathedral was referred to. It displays a glowing brilliancy not subsequently attained.

In the reign of Elizabeth, stained glass was largely introduced in mansions, exhibiting heraldic devices and mottoes. The 17th century led to a notice of several windows by Van Linge, that in Lincoln's-inn chapel being a good example of this artist's productions. Others were enumerated, which belong to the 18th century, but they were not considered worthy of commendation, having been, for the most part, treated as an oil-painting, and with a preponderance of shadow on a transparent medium. At the present day, Mr. Cooper observed, there is a return to the practice of mediæval glaziers, in the employment of flashed glass and pot-metals together with minute lead-work. The east window of Saint James's Church, Piccadilly, he thought creditable in respect of glazing and richness of tone in the colours; but a higher degree of artistic merit might have been readily obtained. A proper gradation of colour in the composition had not been observed; the most elevated figure, viz., that of the Saviour ascending, being inconsistently clothed in scarlet, and which, the reader argued, should have been represented in drapery of the most aërial description. Much controversy and criticism had taken place upon the the character of this window. He said that he could not detect any Gothic details in the window as executed; that the borders are Italian, from works by Raffaelle, G. Romano, and others, and may be seen in Gruner's work. The borders of mosaic-work impart a Byzantine feeling, whilst the various symbols and emblems introduced were commonly employed by the early Italian Christians. He considered that we may expect success in direct imitations of the mediæval works, as seen in new windows in the Temple Church, where the colours and glazing are alike good, and the tableaux, or subjects, being small, do not render any impropriety of intensity conspicuously objectionable.

The east window of the new church in Wilton-place was next noticed as a misunderstanding of this kind of decoration. It is not yet completed; but in the lower portion a failure was said to be clearly indicated. The intention of the designer, the writer supposed to be akin to those prevalent during the transition period, when the introduction of a series of small and separate subjects illustrative of history was aimed at; but omitting the principal charm arising from the harmonious and rich glow emanating from a combination of full-toned colours. The figures in this window were then described as small, on light or white grounds, producing a spotted effect from their size, and also precluding the possibility of readily making out the subject; added to which, each figure, or group, is surmounted by tabernacle-work in pale yellow glass, feebly contrasting with the stone mullions of the window. He then argued, that one of two rules should be observed,—either a rich general effect should be produced (the design or subjects being subordinate), or the subject should be well defined, and sufficiently large to be well understood in any part of the building. Neither of which had been regarded in this last instance.

One great cause of failures at the present day was attributed to the art being regarded as a mere trade; and it was contended, that were artists of eminent talent to devote attention to the principles which regulated the application of colour to this material, we might soon realise our brightest expectations. Much might be hoped for from the great advance taking place in chemical information. The writer suggested improvements that he believed had not yet been applied to stained-glass windows. One was, to introduce "lights" in the representation of objects. Shadow had been freely used, but he argued, that dark shadowing constitutes a great fault. The best effects in a picture generally arise from the lights. By using flashed glass and a partial removal of the coloured surface these might be produced. Another plan by double glazing was mentioned, using two plates of flashed glass of different colours, and subjected to certain modifications by grinding or acid. Specimens illustrating these considerations were exhibited.

By these and other means that might be suggested, together with an avoidance of aërial perspective, a superior pictorial effect would result; and he concluded his paper by a brief recapitulation of the leading characteristics of the design and colouring peculiar to each of the centuries which had been passed under review.

CENTRAL SUN.

At the Royal Irish Academy, Sir W. Hamilton announced the presumed discovery, by Prof. MADLER, of "*a Central Sun*," and exhibited Prof. Mädler's essay on the subject (*Die Central Sonne*, Dorpat, 1846). The following report, containing a sketch of the results arrived at, and which were briefly stated to the meeting, we take from the *Dublin Evening Post*:—

"By an extensive and laborious comparison of the quantities and directions of the proper motions of the stars in various parts of the heavens, combined with indications afforded by the parallaxes hitherto determined, and with the theory of universal gravitation, Prof. Mädler has arrived at the conclusion that the Pleiades form the central group of our whole astral or sidereal system, including the Milky Way and all the brighter stars, but exclusive of the more distant nebulæ, and of the stars of which those nebulæ may be composed. And within this central group itself he has been led to fix on the star Alcyone (otherwise known by the name of Eta Tauri), as occupying exactly or nearly the position of the centre of gravity, and as entitled to be called the central sun. Assuming Bessel's parallax of the star 61 Cygni, long since remarkable for its large proper motion, to be correctly determined, Mädler proceeds to form a first approximate estimate of the distance of this central body from the planetary or solar system; and arrives at the (provisional) conclusion, that Alcyone is about 34,000,000 times as far removed from us, or from our own sun, as the latter luminary is from us. It would therefore, according to this estimation, be at least a million times as distant as the new planet of which the theoretical or deductive discovery has been so great and beautiful a triumph of modern astronomy, and so striking a confirmation of the law of Newton. The same approximate determination of distance conducts to the result that the light of the central sun occupies more than five centuries in travelling thence to us. The enormous orbit which our own sun, with the earth and the other planets, is thus inferred to be describing about that distant centre—not indeed under its influence alone, but by the combined attraction of all the stars which are nearer to it than we are, and which are estimated to amount to more than 117,000,000 of masses, each equal to the total mass of our own solar system,—is supposed to require upwards of 18,000,000 of years for its complete description, at the rate of about eight geographical miles in every second of time. The plane of this vast orbit of the sun is judged to have an inclination of about 84 degrees to the ecliptic, or to the place of the annual orbit of the earth; and the longitude of the ascending node of the former orbit on the latter is concluded to be nearly 237 degrees. The general conclusions of Mädler respecting the constitution of the whole system of the fixed stars, exclusive of the distant nebulæ, are the following:— He believes that the middle is indicated by a very rich group (the Pleiades), containing many considerable individual bodies, though at immense distances from us. Round this he supposes there is a zone, proportionally poor in stars, and then a broad, rich, ring-formed layer, followed by an interval comparatively devoid of stars, and afterwards by another annular and starry space, perhaps with several alternations of the same kind, the two outmost rings composing the two parts of the Milky Way, which are confounded with each other by perspective in the portions most distant from ourselves. Professor Mädler has acknowledged in his work his obligations, which are those of all inquirers in sidereal astronomy, to the researches of Sir William and Sir John Herschel."

Draining with Engine Ashes.—On the farm of Daldorch, the property of Archibald Buchanan, Esq., of Catrine Bank, Scotland, there are drains made 28 years ago, and filled with engine ashes, which are still in full and efficient operation. The depth of drain is 26 inches, and the width between each 12 feet. The bottom of the drain is cut three inches wide, and the depth of ashes used in filling them is about 10 inches. The soil is a firm clay. These drains promise to be as efficient half a century hence as they are at the present time.

LIST OF FOREIGN BOOKS LATELY PUBLISHED.

Civil Engineering, Architecture, and their Collaterals.

FRENCH WORKS.

Czynzki, J., Kopernik—Copernicus and his Works. Paris: 8vo. 6s.

Leroux de Lincy, Hôtel de Ville—History of the Paris Guildhall. Paris: 4to., plates. 25s.

Vignente, B., Irrigateur—Practical and Law Handbook of the Irrigator Paris: 12mo. 2s. 6d.

Bourdat, J. M., Théorie—Theory of Eclipses, and the annular eclipse of Oct. 9, 1847, visible on the ancient Continent. Paris: 12mo.

Granjean de Montigny, Architecture—Tuscan Architecture, Palaces, and other edifices, measured and designed by. Second Edition, with an addition on the Tombs of Italy. Paris: fol., 134 plates. £2 15s.

Klée, F., Déluge—Geological and Historical considerations on the last Cataclysms of the Globe. Paris: 12mo. 3s. 6d.

Paloneeau, A. R., Les Eaux—Practical Treatise on Water. Paris: 12mo., plates. 3s.

Ray de Morande, Examen—Critical Examination of the *Cosmos* by Humboldt, with a new system of the Universe. Paris: 8vo. 2s. 6d.

Vanauld, A., Genie—The Genius of Art; Studies on the most celebrated Painters, Sculptors, &c. Paris: 8vo., plates. 9s.

Batissier, L., Histoire—History of Monumental Art in the Ancient and Middle Ages, with an Essay on Glass Painting. Paris: gr. 8vo., plates. £1 1s., [A very important work.]

Thierry, Jun., Méthode—Graphic and Geometric method of Linear Drawing. Second Edition; corrected by F. C. M. Marie. Paris: oblong 8vo., plates. 10s. 6d.

Chazallon, M. R., Marées—Annuary of the Tides on the Coast of France in 1847. Published at the Depôt of the Navy. Paris: 18mo.

Richard, Chemins de Fer—The Great French North Line, from Paris to Ostend and Cologne. Paris: 18mo., 2 charts on steel. 2s. 6d.

Annuaire—Annuary of the Ecole polytechnique, up to the year 1846. Paris.

Andraud, Système—Atmospheric Railways, after the system of,—Paris: 8vo., plates.

Minard, M., Cours—Course of Hydraulic constructions at Sea-ports, delivered at the College of Roads and Bridges. Paris: 4to., Atlas. £1 5s.

Mignard, B. R., Traité—Treatise, Theoretical and Practical, on Construction. Paris: 8vo., Atlas in folio.

Fontenay, T., Notice—Notice on the Construction of the Tunnels of St. Cloul and Montretout, with general observations on subterranean passages, and the dimensions and prices of sixty-six tunnels in France, England, and Belgium. Paris: 8vo., plates. 5s.

Vicat, L. I., Etudes—Studies on the Artificial Pozzolanas, composed of the natural ores of Italy, and their use in buildings in fresh and salt water. Paris: 4to., pl. 8s.

Prus, C., Tables—Tables on the tracing of Converging Curves (*c. de raccordement*). Paris: 12mo. 5s.

Richard et Quetin, Guide—The Traveller's Guide through Monumental France. Paris: 12mo., chart. 10s.

Montfalcon et Palinière, Traité—Treatise on the Salubrity of large Cities. Paris: 8vo.

Application of the Properties of actual Celerity to the different conditions of Stability of Vaults and Dressings, by General Count L. Paris: 4to.

St. Claire Déville, Etudes—Geological Studies on the Islands of Teneriffe and Fogo. Paris: 4to.

Adhemar, J., Perspective—Perspective of distant objects, being a Supplement to the Treatise on Perspective. Paris: 4to. Atlas in folio.

Sommeraud, F., Arts—The Arts in the Middle Ages, Roman Palace at Paris, Hôtel de Cluny, &c. Paris: Five volumes, 8vo.

Normand, Modern Paris—Villas and Rural Constructions about Paris; plans, elevations, and general outline of their architecture. Paris: 8vo., plates. Each Part, 2s.

France.—Caen, Feb. 2.—A basin for the accommodation of shipping is in progress at this port. To render it of more service, a canal from the town to the sea (which are eight miles apart) will, it is hoped, be completed during this year. At present, ships have to thread the shallow and serpentine Orne to reach the town. A harbour of refuge is also in course of construction at Port-en-Bersin, which will be invaluable, not only to French, but to English shipping, there being now no place of refuge between Havre and Cherbourg. The proposed harbour is nearly opposite to Chichester, in Sussex, and, when complete, will be capable of floating men-of-war.

AMERICAN PATENTS.

Improvements in the portable forge. C. V. Queen, Peeksville, New York. The forge is provided with shutters, which slide around to enclose the fireplace when not in operation. The forge fan is provided with a pipe which communicates with the bellows, and from this pipe there is a branch provided with a valve, so that air can be admitted to the fire, when the bellows is not at work.

Improvement in the method of letting down and raising propellers. R. F. Loper, Philadelphia, Pennsylvania.

It consists in attaching two screws to cog wheels on the deck of the vessels, which mash into a large cog wheel on the drum of a capstan, the threads of the screws taking into nuts formed in the sliding frame of the propeller, the sides of which frame are bored out cylindrically to a certain depth, to admit the screws to pass therein, and to protect them from the action of the salt water deposits and rust, which would otherwise prevent their working.

Improvements in water wheels, William Dripps, Coatsville, Pennsylvania, consists in making the apertures in the wheel, for the introduction of the water to the buckets, to extend through the outer or cylindrical perimeter thereof, near the top, and then spirally down through, between the buckets, to the bottom thereof, in the manner described, in combination with the funnel-shaped inner rim and curved buckets; and also the combination of the sliding frame, and segment valves connected therewith, by rods or stems of unequal lengths, for letting on the water by degrees.

Improvements in truss frames of bridges, Nathaniel Rider, South Bridge, Massachusetts, relates to the mode of producing the camber of the truss, by distension wedges, or apparatus, applied between the ends of the bars of the upper stringer, or chord, in *combination* with the contractile and cambering chain, made and applied to the lower or other suitable part of the truss. The wedges are applied at the junctions of the pieces composing the upper stringer of the arch, and below the arch there is a chain made in two parts, and connected by a swivel screw, for the purpose of shortening the chain which supports the arch.

Improved method of indicating the height of water in steam boilers, George Faber, Canton, Ohio; consisting simply in attaching a magnet to the axis of motion of a wheel or lever, to which the float is suspended or attached, to communicate motion by attraction and repulsion, to an index needle turning on an axis outside the boiler, and separated from the magnet by a steam-tight plate.

Improvement in the steam engine, R. F. Loper, Philadelphia, Pennsylvania; consisting in rotating two crank shafts with equal velocities and in opposite directions, by means of a connecting rod, extending from the cross-head of a steam engine to the two crank shafts, the centre of vibration of the cross-head being centrally between them. The claim is for connecting the cross-head of a reciprocating engine with two crank shafts on opposite sides of, and at equal distances from, the centre of vibration, by means of a connecting rod or lever turning on the cross-head, and reciprocating with it, and taking hold of the cranks on the two crank shafts, by which they are caused to turn in opposite directions, and with equal velocities, as herein described.

Improvements in the steam engine, William A. Lighthall, Albany, New York; consisting of the arrangement and disposition of the steam chests, side pipes, condenser, exhaust pipe, bed plate, and air pump, in combination with the cylinder lying horizontal upon the solid keelson or frame, said cylinder being in the hold of the vessel, below the deck beams. Second, the mode of working the valves whole and half stroke, by the combination of the eccentric wheel, eccentric hook and branch hook, the heart cam and cam hook, together with the hollow rock shaft, substantially as described, in combination with the cylinder in the aforesaid horizontal position.

Improvement in the water wheel, William Lamb, Whitestown, New York, consists in the construction of water wheels designed to run under water, with one, two, or more floats so placed in relation to the shaft and body of the wheel as to form a short transverse section of a screw of one, two, or more threads respectively—to be made of any suitable material, and of a shape that may be moulded and cast whole, or to be made of wood, or part of each—in combination with a coiled or scroll trunk, so made as to bring the water in contact with one side of the wheel, and conduct it around the wheel in the direction the wheel runs (except what is discharged in its passage) the trunk being diminished in size gradually by drawing in the side or sides, or by gradually raising the bottom, or both, so that the size of the trunk at any given point, shall be adapted to the quantity of water remaining undischarged at that point, in its passage around the wheel under the floats; said trunk to be made of metal or wood, or part of each, and of a size and form best adapted to the circumstances.

REGISTER OF NEW PATENTS.

SMELTING COPPER ORE.

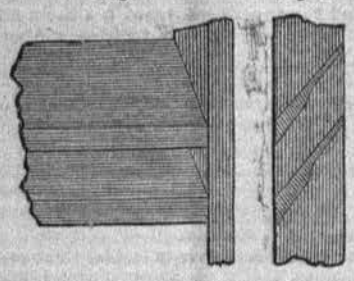
THOMAS BELL, of Don Alkali Works, South Shields, for "*Improvements in smelting copper ore.*" Granted July 23, 1846. Enrolled Jan. 23, 1847.

These improvements relate to obtaining sulphuric acid from copper ores during the roasting, by placing the ore in powder on the shelves of a common roasting furnace, to which a roasting kiln is attached by a flue, which enters two feet from the bottom, from 150 to 200 feet in length; in this kiln copper ore, in lumps, is put; near the end of the flue there is a jet of steam, which increases the draught; coke, anthracite coal, or charcoal, may be used instead of bituminous coal. The top of the kiln is arched over, and a flue passes through the top into a vitriol chamber. Near the end of this flue also there is a steam jet. During the roasting of the ore, sulphurous acid is formed, which, in passing through the flues, is mixed with the aqueous vapour, and partly becomes condensed into sulphuric acid; in this state it passes into the vitriol chamber, and collects on the floor; at the same time, the uncondensed sulphurous acid gas and steam, on passing into the vitriol chamber, meet with nitrous acid gas, produced by acting on saltpetre, or nitrate of soda, by strong sulphuric acid. But that portion of the sulphurous acid which escapes condensation is afterwards condensed in columns of coke, previously exhausted, as described in a former patent (Nov. 3, 1845), "for improvements in the manufacture of sulphuric acid," or by means of a high chimney.

AREA GRATINGS.

RICHARD MARVIN, of Portsea, Southampton, gentleman, and WILLIAM HENRY MOORE, of Southsea, gentleman, for "*Improvements in gratings of metal or wood, for the fronts of houses and general purposes, for the admission of light and ventilation.*"—Granted May 28; Enrolled Nov. 28, 1846.

Fig. 1. Fig. 2.



This invention relates to constructing gratings of wrought or cast metal, or wood, as shown in the annexed engraving; fig. 1 is a plan of part of a grating, and fig. 2 a section. The bars are fixed in the frame in such a manner that the top of one bar shall cover the bottom of the next bar. The length of the frame is regulated by the number of bars; it is 2 inches deep, and $\frac{3}{8}$ inch thick. The length of the bar depends upon the size of the required grating; the depth of each bar is 3 inches on the top side, and $3\frac{1}{2}$ inches on the under side; the thickness is $\frac{3}{4}$ inch on the top edge, gradually reduced to $\frac{5}{8}$ inch in the middle, immediately beneath which it is reduced to $\frac{5}{16}$ inch, and then gradually reduced to $\frac{1}{4}$ inch at the bottom. The distance from one bar to another is $1\frac{1}{4}$ inch at the top, which is increased to $1\frac{7}{8}$ inch at the bottom.

HOUSE PAINTING.

HAROLD CREASE, of Brixton-hill, Surrey, paper stainer, for "*Improvements in the preparation of paints and colours for decorative and other similar purposes.*"—Granted July 23, 1846; Enrolled January 23, 1847.

The invention relates to the preparation of colours, whereby they are rendered suitable for painting "flatting or dead white;" the colours so prepared will be free from any offensive smell, dry quickly, and be ready to receive a second coat within an hour after the application of the first. The improvements consist in combining shellac, gelatine, and animal or vegetable oil, with an alkaline base, and incorporating this mixture with ordinary paint, in the following manner:—Boil $2\frac{1}{2}$ lb. of well-bleached shellac and $\frac{1}{2}$ lb. of borax, or other suitable alkaline base, in five quarts of water until dissolved; the boiling to be continued until the solution is reduced in bulk to about one gallon. To one quart of this solution, from half a pint to a pint of pure gelatine, according to its strength, and four drachms of alcohol are added, and gradually incorporated therewith by the application of heat. The mixture is then added to the remaining portion of the solution, together with the requisite quantity of white lead to give it a body, and a small quantity of well-bleached oil; the latter ingredients being added in the proportion of 9 lb. of white lead and two ounces of oil to each quart of the solution. This mixture is ground in an ordinary paint mill, and afterwards thinned with a solution of shellac: it is then ready for use. The preparation is applicable to all colours used by painters, excepting a few containing iron.

GAS APPARATUS.

AUGUSTUS WILLIAM HILLARY, Esq., of Chelsea, gent., for "*Improvements in the manufacture of gas.*"—Granted July 23, 1846; Enrolled Jan. 23, 1847.

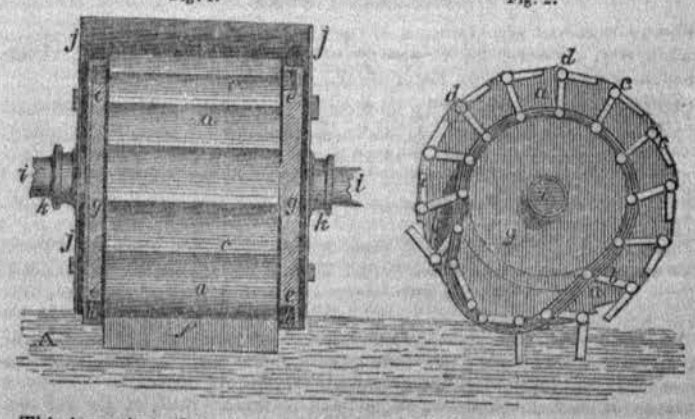
The objects of the improvements are, first, for separating the condensible matters from the gas at one operation; secondly, for converting bituminous matters into gas; thirdly, for decomposing the condensible matters, by passing steam over them in the heated tubes; fourthly, the obtaining from the pitch, tar, &c., matters capable of enriching the gas. These objects the patentee proposes to obtain by the arrangement of apparatus, consisting, first, of a retort, which is of an oval form in front, with one end rounded, and within which are placed, lengthwise, three parallel tubes, reaching nearly the whole length; the ends of the tubes towards the back are open. The tubes contain, to about three quarters of their length, twisted plates of metal or other suitable material. From the centre one of these tubes, which is larger than the other two, a tube rises to a considerable height, and then turns downward again in the ordinary manner of refrigerators, the end dipping into a condenser. This condenser is a rectangular receiver divided into eight compartments. The tube above mentioned dips into the first of these compartments, from this again another tube passes to an equal height with the first, and dips into the second compartment, and so on throughout the several compartments to the last in the series; from which a tube passes into the hydraulic main. From the ends of the two latter tubes above described, two smaller tubes rise and enter the front of the condenser; these tubes have such a form that by a bend in the horizontal portion, it acts as a syphon, and prevents the gas rising from the retort by these channels into the condenser. From the back of the condenser there is a syphon, which can be opened or shut at pleasure; this syphon, if required, will conduct the tar and ammoniacal liquor to the furnace.

When the charge of coal in the retort is being decomposed, the gas and vapours formed pass (by the middle tube above described) up and down the series of pipes in the refrigerator, depositing the tar and other condensible matter in the condenser, from which the fluid matters, viz., water containing ammonia and sulphurous acid, and tar, flow by the two syphons first above mentioned, into the two tubes within the retort; here, coming in contact with the heated metal plates, these waters, the patentee states, are decomposed; the metal becoming oxide of iron by the decomposition of the watery vapour, at the same time that the free hydrogen unites with the carbon of the pitch and tar, it forms a superior gas. Coal contains besides sulphur, ammonia; the steam in passing over the oxide of iron formed in the tubes, enables it to absorb a larger quantity of sulphur. In this manner the metal is converted into sulphur of ammonia and iron, and the gas sufficiently purified for ordinary purposes; but if it be used in private houses, it is to be further purified by passing it through sulphuric acid, diluted with three proportions of water, and then through lime before entering the gasometer.

PROPELLERS FOR STEAM VESSELS.

PETER CLAUSSEN, of Leicester-square, Middlesex, gentleman, for "*Improvements in methods of an apparatus for propelling and exhausting and compressing air and aeriform bodies.*"—Granted July 23, 1846; Enrolled Jan. 23, 1847. (Reported in the *Patent Journal.*)

Fig. 1. Fig. 2.



This invention relates to propelling vessels from the stern. With this view, the patentee employs horizontal propeller shafts, attached to the pistons of two steam cylinders; the ends of these shafts, which pass through stuffing-boxes into a watertight casing, are affixed to frames or chases, subdivided into twelve or more compartments, for the reception of an equal

number of swing floats, which open one way, to admit of little resistance to the return stroke. These propellers, which move in a line vertical with the rudder of the vessel or boat, are thrust or driven, by the action of the steam piston, forward in the direction with the line of motion of the vessel or boat; the mode of reversing being the alteration in the direction of the float boards to the required direction. The patentee claims under the first head of his specification the mode of, or apparatus for, propelling boats or vessels from the stern by suitable means hereinafter described.

The second part of the specification relates to the mode of an apparatus for propelling vessels or boats by the means of circulatory revolving paddles. In constructing float wheels according to this invention, instead of applying float boards to hollow frame wheels, the patentee attaches them to cylindric drums having suitable recesses formed in their peripheries for their reception. Fig. 1 represents an end view of the improved wheel, and fig. 2 a sectional side elevation taken through the dotted lines, A B. *a a*, is the cylindrical drum which may be of metal or any other light substance, such as cork, wood, or otherwise. *b b*, are float motion rods, attached at right angles by the hinge or joint *d*, to the float boards *c c*. *e e*, are small friction rollers, which turn on centres at the ends of the motion rods *b b*, for the purpose of directing the position of the float boards; *g g*, are slottled bridles or guides, in which the friction rollers *e e* travel; these, rollers, when moving concentric with the drum *a a*, remain stationary, but when they diverge into the eccentric channel *h h*, they cause the free use of the float boards to move outwards, till, on arriving at a point coincident with a vertical line drawn through the centre of the drum, they present the whole of their surfaces to the water, as seen at *f*; *i i*, is a crank shaft passing through stuffing boxes, *k k*; *j j*, is a water-tight casing, enclosing the paddle-wheels. The inventor states that wheels so constructed are to be placed in the hold of a vessel or boat, on each side of the keel, transversely, and driven by steam or other motive power engines; and he claims under this second head of his invention, the mode of, or apparatus for, propelling vessels or boats, by circulatory revolving paddles, as hereinbefore explained.

The third part of the specification relates to the construction of vessels or boats formed with bottoms of double curves and double bilges, the object of which is to enable those on board to ballast the vessel or boat when necessary; for this purpose the patentee employs an air-pump in connection with a bulk-head, or longitudinal channel in the hold of the vessel or boat; each boat or vessel having double curved bottoms, with double bilges, are formed like two boats or vessels placed side by side; these double curved bottoms are boarded over, forming the floor of the vessel or boat, and between which an air-pump and suitable apparatus is employed to drive the bilge water out, or let other in: the action of valves opening outwards as well as inwards causing the water (by a pressure of air from the air-pump, on the surface of the same, between the bulk-head or longitudinal chamber) to be driven out through the bilge at the bottom of the vessel. The inventor claims under this third head of his invention, the method of, or apparatus for, constructing vessels with double curves and bilges, for purposes of ballasting, or driving the bilge water from the vessel or boat, through suitable valves in the bottom of the vessel or boat.

The fourth part of the specification relates to the mode of, or apparatus for, propelling boats, vessels, barges, carriages, and vehicles, by the means of pulley wheels attached to the vessel, or carriage, to be propelled, and driven by steam or other motive power, by fixing a rope or chain at each end of the road, or canal, and passing it over the pulley wheels in a suitable manner to be acted upon.

The patentee claims lastly, the mode of, or apparatus for, propelling vessels, boats, barges, carriages, carts, agricultural implements, and vehicles, by the application of wheels, pullies, ropes, or chains, for the purposes herinbefore described.

TESSELLATED WORK.

Henry Austin, and Thomas Webster Rammell, of 10, Walbrook, London, civil engineers, for "*Improvements in wood mosaic, and tessellated work.*"—Granted June 20; Enrolled, December 20, 1846.

The improvements relate, first, in the application to wood mosaic and tessellated work of an elastic and easily-compressible material, surrounding each separate square or tessera. Second, to the mode of putting together and forming such work when the tessera is square, with such elastic and easily-compressible material surrounding each square or tessera, as shown in figs. 1, 2, 3, 4, 5, and 6.

Fig. 1, shows a block of wood mosaic, and tessellated work, in its final state of preparation, with a full design or pattern running through it, and merely requiring to be cut into sheets of the required thicknesses, for use in the manner after described. Figs. 2 to 5 represent five different blocks of the various coloured woods, forming part of the design or pattern in fig. 1. Fig. 7 represents a block of the wood mosaic, and tessellated work, showing the introduction into the design or pattern of diagonal work.

Planks of convenient thickness, of well-seasoned woods, of the colours and descriptions desired, and as to colour, either naturally coloured or to be produced artificially, are to be taken at the stage of the manufacture hereinafter pointed out, and cut into separate pieces of a convenient length and width (say 9 in. by 4½ in.) They are planed to an exact thickness, corresponding with the size of the square or tessera of the intended mosaic, these pieces being regulated according to the design intended. Then sheets of cork are taken and carefully cut or prepared to a thickness in proportion to the size of the square or tessera, (about $\frac{1}{20}$th); the cork is then trimmed or fitted to the length and width of the before-mentioned pieces of wood; and pieces of wood and sheets of cork are then glued or cemented alternately together, forming them into different blocks, such blocks being regulated in number by the number of the compartments into which

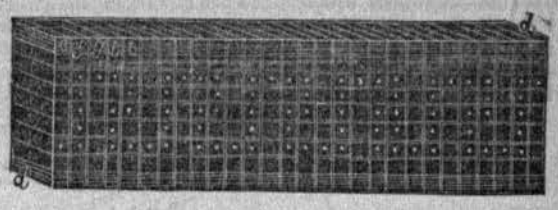


Fig. 1.

Fig. 2.

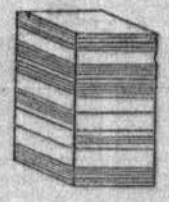


Fig. 3.

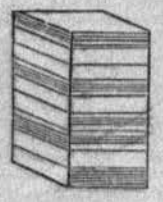


Fig. 4.

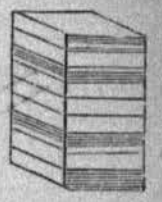


Fig. 5.

Fig. 6.

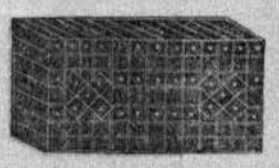


Fig. 7.

the intended design or pattern may be divided; for instance, in the desig or pattern shown at fig. 1, the full design or pattern, it will be seen, i divided into, or consists of, five compartments, and there are, consequently five of these blocks, similar to figs. 2 to 6, each block being confined to its distinct compartment of the full design or pattern, as shown at *e*, *f*, *g*, *h*, *i*, in fig. 1; and in forming and making up these blocks, the different coloured and description of pieces are to be arranged in the order required to form the pattern. These blocks are next cut up, arranged, and prepared, after the following manner, viz.:—when it is desired that the mosaic should be prepared with the grain or fibre of the wood vertical, or nearly so, first cut the blocks so arranged, in half, in the direction of the dotted line, *d* fig. 2, and then cut each of the halves into separate planks, or pieces of the required thicknesses, in the direction of the dotted lines, *b*, *b*, *b*, as shown in fig. 2; and when it is desired that the mosaic should be prepared with the grain or fibre of the wood horizontal, then cut the blocks so arranged across, in the direction of the dotted lines, *c*, *c*, *c*, as shown in fig. 6. Afterwards plane these separate planks or pieces to the exact size of the square or tessera of the work, and then proceed to make up the block of the full design or pattern, as shown at fig. 1, in the following manner:—take the plank from each of the separate blocks, 2 to 6, and then glue them together, in the order of the pattern and of the numbers of the blocks, with other sheets of cork cut and prepared, and of the thickness as before described, alternately together; then continue on as before, repeating the making up of the full design to the desired length of the block, as shown at fig. 1, as to which, about thirty inches will be found a convenient length. The block thus obtained is then to be sawn in the direction shown by the dotted line, *d*, *d*, *d*, into sheets of the thickness desired (say $\frac{1}{16}$ths of an inch), and each sheet will present precisely the same design or pattern, and each square or tessera be surrounded by the cork so introduced in the work as before mentioned, and be in a state for use according to the purpose for which it is intended, excepting that, in cases where wood to be artificially coloured is used, these sheets, or such parts of them as are intended to be artificially coloured, will first require to undergo that process, which is well known, it being at this stage of the manufacture that it is preferred to colour the wood when it is artificially coloured.

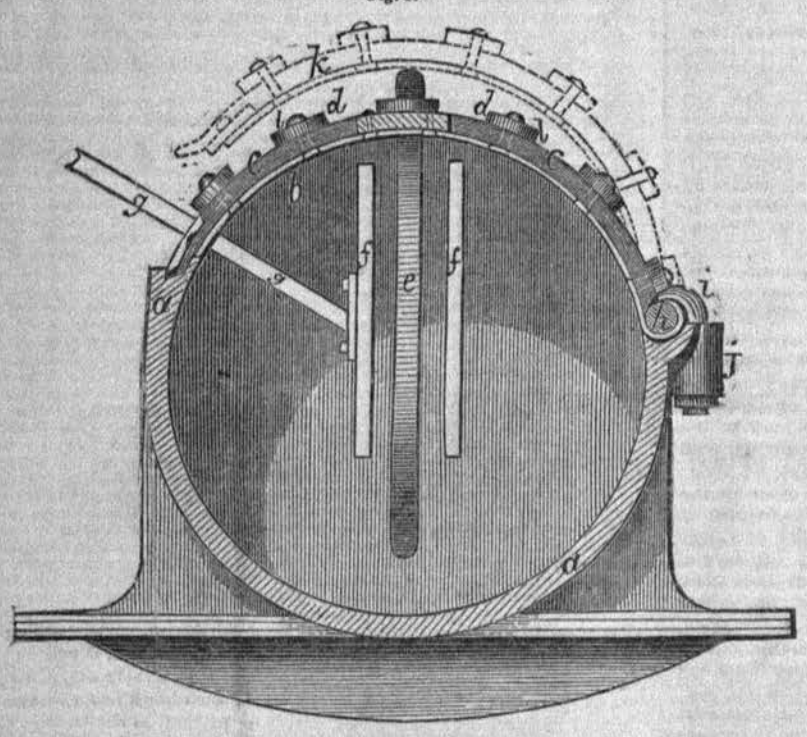
This mosaic and tessellated work is applicable to flooring, panelling, and veneering, for building purposes; also to all purposes of cabinet work, furniture, and useful and fancy articles for which veneers are now commonly used, and in the finer sorts, where the square or tessera does not exceed three-fourths of an inch, may be used as a loose covering. When used for

the purpose of making floorings and wainscotings, or panellings against walls, it is preferred, before fixing it, to fasten each sheet of the mosaic, so prepared, upon a separate suitable ground-work or foundation; for this purpose a double set of thin boards, glued or cemented together transversely to each other as to grain, does extremely well.

When used as a loose covering, it is fastened on to a thin surface of papier maché, or felt, or a preparation of india rubber and cork, known by the name of kamptulicon, or other suitable material. The material we have named throughout the description already given of this invention, as the surrounding material for the square or tessera, has been confined to cork, and which is the material preferred by the patentees; but any other material which may be of an elastic or easily-compressible character, such as caoutchouc in its various states of preparation, or soft leather, papier-maché, felt, gutta percha, and other materials partaking of the like properties, will answer the purpose; some of the materials here referred to for surrounding each of the squares or tessera, may also be applied in a fluid, or soft, or plastic state, and poured or pressed in between the squares or tessera, instead of being applied in the way described.

In diagonal work, where the tessera of the mosaic is otherwise than square, it is to be made up in the usual way of preparing and forming inlaid work when made up into blocks, except that the elastic and easily-compressible material before described all round each tessera, is introduced; and where combined with work in square tessera, as shown at fig. 7, the principle of making up the pattern is applied, when formed of square tessera as already described, as far as it may be practicable.

Fig. 1.



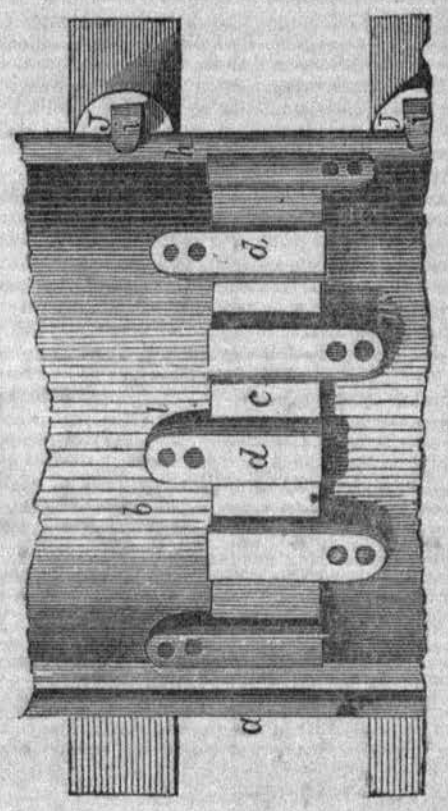


Fig. 2.

ATMOSPHERIC RAILWAY TUBES.

WILLIAM WARCUP, of Ashton-terrace, Coronation-road, Bristol, civil engineer, for "*certain Improvements in the manufacture and arrangement of parts and apparatus for the construction and making of atmospheric railways.*"—Granted Aug. 11, 1846; Enrolled Feb. 11, 1847. (Reported in the *Patent Journal.*)

This invention relates to an improved method of manufacturing the traction tubes for atmospheric railways, in which the driving pistons work these tubes, which are of cast iron or other suitable metals, made in the ordinary manner, but differ only in the construction of the longitudinal valve, which is formed of different segments (answering a double purpose, by forming the top portion of the traction tube as well as the longitudinal valve), each segment being formed by layers of flexible material, such as india-rubber, leather, or other elastic substance, placed between metal plates of given lengths, admitting by its flexibility a free passage to the piston rod. Fig. 1 represents a transverse vertical section, and fig. 2 a plan view of the top, showing the longitudinal valve; *a a* is a cast iron tube, or traction pipe; *b* is a metal segment of the longitudinal valve; *c c* is the outer segment or flexible portion of the same; *d d* are four lifts, two of which are attached by their ends to one side of the segment, *l*, and the two alternate ones to the other, *m*, by which it will be seen that, as they press upon the flexible substances, *c c*, they keep the joint, indicated by the dotted lines, hermetically sealed; *e* is a lifting valve wheel, which travels with the piston on the frames, *f f*; *g* is a piston motion rod, which is attached to the carriage, when motion is given to the piston by an external atmospheric pressure; the wheel *i* raises, as the piston advances, the alternate segments of the valve, shown by the dotted line *k*, forming an open channel for the transmission of the arm *g*; *h* is a circular bar or hinge, on which the valves turn; *r r* is a belt or loop, passing through the semicircular bearing *j*, and over the rod or hinge, *h h*. The inventor states that he does not confine himself to the whole of the details herein given, so long as the important peculiarity of his invention be retained; but he claims the use of an atmospheric tube, divided longitudinally into two parts, whether connected by hinges or not, and forming a complete tube, ready for exhaustion when closed, the longitudinal connection and joint between the top and bottom parts of the tube being effected without having recourse to the elasticity of the material of which the tube is composed, or the intervention of an elastic or flexible material, to form a hinge, as at present used in the construction of Clegg and Samuda's, closing entirely by the weight of the upper parts, without the assistance of springs or other mechanical contrivance. He claims also the longitudinal ribs forming the abutment for the top valve, or the other half of the tube.

METAL ROLLERS.

THOMAS PAYNE, of Handsworth, near Birmingham, gentleman, for "*Improvements in the manufacture of rolls, for rolling iron and other metals.*"—Granted August 4, 1846; Enrolled February 4, 1847.

This improvement relates to the mode of rolling iron and other metals. Heretofore the rolls have been cast with necks or axles at their ends, which are liable to be broken when in use; and it has also been attempted to cast rolls on to bars of iron, to strengthen the axles or necks; but in such cases the inventor states that bars of iron so used are much injured, and being weakened, are unfit for such purposes. The patentee proposes to cast the rollers of any given size required, hollow, so as to admit of the shaft or axis being passed through, and fixed therein by keys or otherwise; care being taken in casting that the hollow space within a roller is cast or formed truly, so that the shaft when introduced shall fit accurately, allowing spaces for